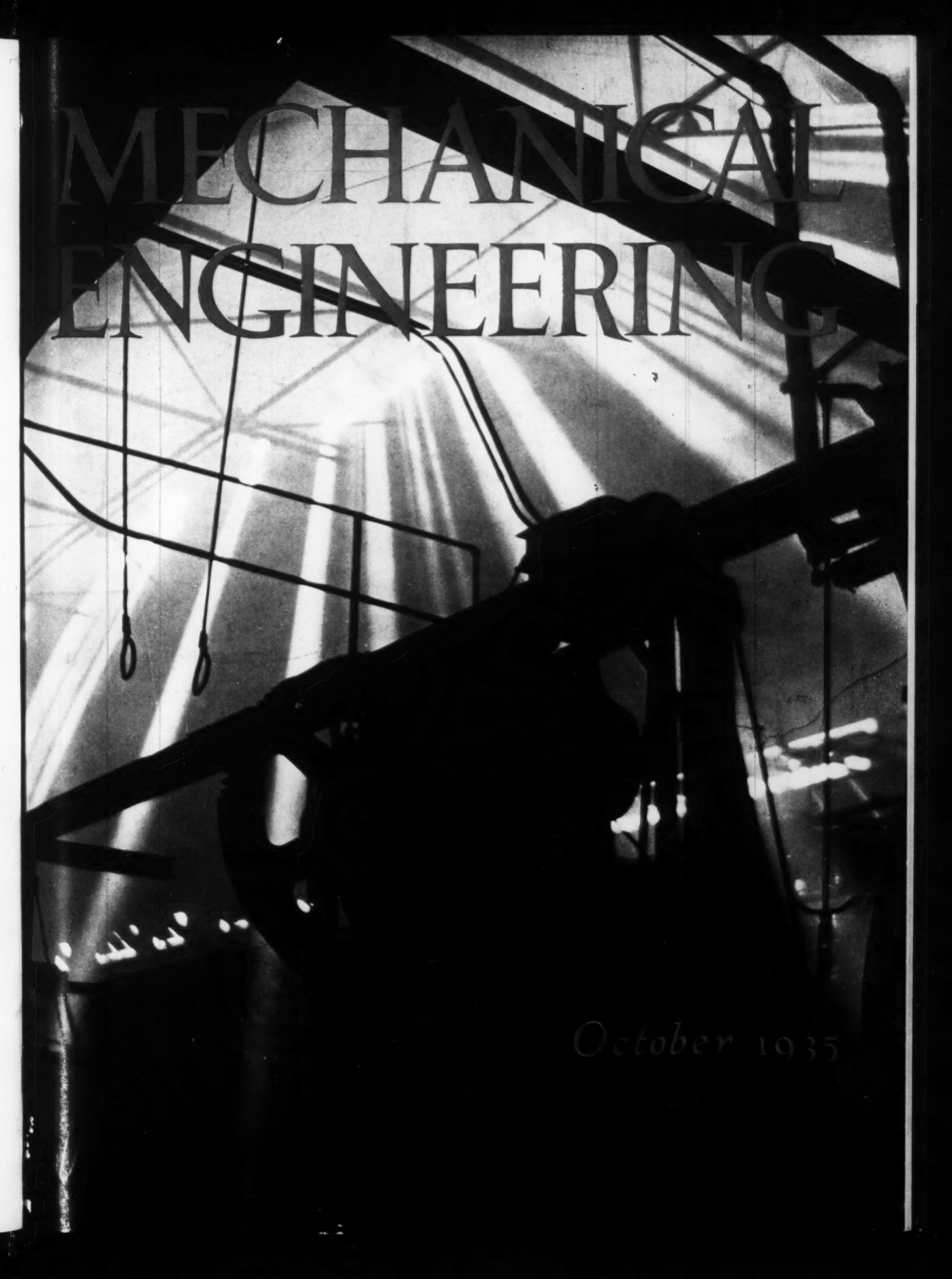
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G-67

MECHANICAL ENGINEERING

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Young and Phelps

"This is not a machine age . . . It is a great man age . . . These machines that we talk of are simply small tools that men have devised to enable them to do a better job. We are going to continue on in this man age because men are doing more and better thinking than ever before."—Thomas J. Watson, president, International Business Machines Corporation, at the "Preview Dinner," Machine Tool Show, Cleveland, Ohio, Sept. 10, 1935

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MECHANICAL ENGINEERING

OCTOBER
1935

GEORGE A. STETSON, *Editor*

The Housing Question

LITERATURE on housing is accumulating as interest in this pressing subject grows. Elsewhere in this issue, in one of a series of book reviews, a comprehensive survey of a recent book on this subject is presented. A helpful summary of some of the European experiences and their economic implications is to be found in "Economic Stabilization in an Unbalanced World," by Alvin Harvey Hansen (Harcourt, Brace and Company), in a chapter, "Social Control in Housing." It is recommended for collateral reading.

Signs of Growth

ABOUT thirteen hundred members of the Student Branches of The American Society of Mechanical Engineers become eligible for transfer to Junior membership every year. One measure of the success and vitality of the Society is to be found in an increasing number of transfers actually made. Such an increase is a vote of hopeful confidence on the part of the young men who take this step. The Society's problem is to foster this rate of increase and to convince those who complete the transfer that they have made a wise decision in doing so. Both phases of the problem are of immediate interest to members.

One way in which the student member is convinced that he should apply for the transfer is through the successful administration of the student branch to which he belongs. Far from being entirely a local matter, this administration may be good or bad as it reflects the leadership and interest of the parent Society. To this cause a modest publication, known as the "Student Branch Bulletin," is prepared and distributed with MECHANICAL ENGINEERING to every student member during the eight months of the school year. It is the students' paper. This year in order to bring this publication closer to the interests of college men it is being prepared and edited for the first time by a group of junior members from the Metropolitan district, themselves close enough to undergraduate days to have the campus point of view, and so immersed in the sensations of junior membership that they see the Society through youthful eyes.

Great expectations are held for the success of this venture. It should serve to provide a closer link between the collegiate and the practicing groups, and its effectiveness should be reflected in an increased number of transfers to junior membership next year.

The second phase of the problem—that of convincing the young man that he was wise in making the transfer to junior membership—can become a personal responsibility with every member. In its comprehensive view of the development of the economic and professional status of the engineer from preparatory school to fully certified membership, the E.C.P.D. has made helpful suggestions about the recently graduated junior member. Already in some local sections juniors are organized and are carrying on their own activities, and in others close relationships of a helpful nature are being set up between the young and the mature member as individual to individual. In such a program every member can find his place. Broadly and consistently developed, these relationships are powerful influences in making the Society of value to the younger members. Engineers who are not engaged in such work and who would like to take it up will find their services gratefully acknowledged. Why not try it?

For Better Publications

VIEWING with wonder and admiration the progress in machine-tool developments on display at Cleveland, we could not help wondering—a little sadly—if similar progress could be noted in technical literature. Have the publications of engineering societies increased in quality, in value, and in significance in anything like the degree that made machine tools at the show the subject of such favorable comment?

It is a far cry, for example, from the few precision devices available to shop men when George M. Bond made his memorable study of standard measurements more than fifty years ago to the many beautiful instruments displayed at Cleveland, the products of the department he served so many years at Pratt and Whitney. What developments and improvements, comparable with those in mensuration and gaging, are to be found in technical writing since 1881 when Mr. Bond presented that compact little paper on "Standard Measurements?"

It would be useless to continue such a comparison of cabbages and kings. After all, in the manufacture of gages we have made a more permanent transfer of skill to the machine than we shall ever attain in the writing of a technical paper. For in the preparation of manuscripts

there still persists the inevitable carelessness and sloppiness that result from inexperience or temperament or something worse. Men who pride themselves on their ability to read instruments correctly apparently do not take the trouble to read their manuscripts. Designers whose machines function perfectly supply illustrations that have to be corrected—frequently after the cuts have been made. Experts who top all others write so obscurely that few can understand them. Researchers trained to make accurate observations supplement their papers with references to the literature that are misleading and almost useless because of mistakes in names and page numbers. If the accuracy and quality of the work were to be gaged from the manuscript, how little faith would we have in the author! Most authors have lots to learn about preparing manuscripts in such a manner that the fruits of their investigations and experiences are most efficiently passed on to their fellows.

The room for improvement, however, does not cease with the author. A rich and useful literature needs careful selection. In The American Society of Mechanical Engineers, with its broad fields of interest, the Committee on Publications must look for authoritative opinion to reviewers expert in the subjects on which papers are written, and to the sponsoring groups—the divisions and committees—for soliciting and recommending for publication only the best. The Society's responsibility lies in providing outlets for these papers in adequately financed publications and a trained and competent staff to turn out a finished product that will stand as high in its field and represent as great progress from year to year as the products of the machine-tool builders do in that field. Apparently we are all vulnerable.

Salute to an Industry

A KEEN British observer of recent tendencies in this country has emphasized with blunt frankness that it is much easier to plan than to administer. Here he places his finger on the universal truth that plagues all planners, whether their plans are well or ill conceived.

If we inquire into the reasons for the failure on the one hand of the NRA, and the bright promises for early revival of prosperity in the machine-tool industry, we must give a larger measure of credit to the effectiveness of administration in the two cases—imposed authority from without and the top in one, and the intelligent attention to self-interest viewed against the common prosperity of the industry and the country on the other. For among other things the difference between the NRA and the machine-tool industry is the same as will always exist between the effective and efficient administration of a representative private enterprise and a representative state, county, or city government—the difference in the abilities of the administrators in the two cases and their interests and opportunities.

Not every industry in this country has in its ranks the high quality of man power in administration and the ranks that characterize the machine-tool industry. This industry is particularly fortunate in this regard. Even a casual stroller about the 1935 Machine Tool Show could not fail but be impressed with this fact. The men in uniform khaki work coats worn by demonstrators at the show and those in business dress who represented the executive, production, engineering, and sales staffs of the machine manufacturers were representative of the high quality of intelligence that gives to the machine-tool industry its superior standing in the life of the nation. Only organizations with this quality of intelligence in its leadership and its ranks could put to such fruitful use the harrassing years of idleness imposed by the depression, could have kept themselves alive and intact, could have designed and built such remarkable machines. Before quality, precision, and control can be achieved by machines, these characteristics must be fundamental to the natures of the men that fashion them.

Thus it is, in a true sense, as Thomas J. Watson said at the "Preview Dinner" at the opening of the show, that this is the age of men, rather than the age of the machine. Only as men are intelligent, industrious, and resourceful can they impart these qualities to machines.

It is an honorable heritage these men enjoy, one that in most cases can be traced back, as J. W. Roe has done, to the early mechanics of New England whose names still persist in the designations of present enterprises. From these early shops went skilled mechanics to form their own companies and train others who repeated the evolutionary and widely spreading process. For not only are the machine tools capable of self-reproduction, but their makers have been extremely successful in developing men who launch new enterprises. Thus it is that in the machine-tool industry we find at the top men who started in the shop and who succeeded through ability and industry. They represent the truly American opportunity of reaching the top through honest effort; and because so many of them have traveled this course, they are more than usually familiar with the problems—personnel and financial as well as technical—that the industry constantly faces. They have seen their ideas take shape in tools and machines, and in organizations of men in shops and offices. They have learned the courage and patience necessary for success against obstacles. They have met the obligations of keen competition for which merit alone in the machine would offer any reward. They have faced the sobering responsibility of meeting payrolls, and their realization of what unemployment means to skilled workers is more real and more practical—yes, more humanitarian—than that of social reformers and political demagogs.

Still responsive to the inspiration gained at Cleveland, then, we salute this industry for its courage and initiative in being ready at the dawn of returning good times with the machines, and organizations to turn them out, that the manufactures of this country will sorely need in the next few years. And we salute the men in this industry—the men in all ranks who have shown themselves able to design and build—to plan and to administer the plan.

Ewing Galloway

THE FAMILIAR COLONIAL MILL WITH OVERSHOT WATER-WHEEL—THE JOHN WINTHROP MILL AT NEW LONDON, CONN.

The Technical Ancestry of GRAIN-MILLING DEVICES

By RUSSELL H. ANDERSON

MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, ILL.

MILLING, one of the oldest of the mechanical pursuits of man, may be considered from its economic and social side, its relation to power, its general mechanical problems, or the principles employed in the mill itself or some of its parts. We are here concerned almost exclusively with the mechanical principles as exemplified in the mill, or that part of the equipment used in the reduction process.

When the origins of settled agriculture, built upon grain, are found there we may look for the beginning of some form of grain-milling device. Since no important civilization has been developed without grain, the mill has ever been the handmaiden of material culture. Indeed, the makers of the first mills have been called the first mechanical engineers. Certainly grain milling "may claim rank among the first fruits of man's inventive genius." In tracing the evolution of the milling device, it must be kept in mind that while it has been elaborated and improved it has ceased being the whole mill as in the case of the muller, for example, and has become one among many devices, such as cleaners, tempering bins, purifiers, and aspirators, in a modern flour mill.

The stand of rolls and the hammer mill represent the art today in the milling of flour and the grinding of feed. These two milling units come to us by two distinct lines of development, which, with a minor third, represent the principal lines of technical progress in milling. This article will recount the fortunes of each of these "First Families in Milling" by pointing out the succeeding generations, showing wherein modifications have been made and indicating the rise or fall of the importance of each type of mill. In some cases we can say with reasonable certainty that one mill did develop from another, but in other instances we can only point out their similarities and differences, the known facts about their use, and leave the direct connection to inference. In treating the subject, we shall follow the line of thought expressed in Fig. 1, which may be consulted in connection with the text.

Except as otherwise noted, illustrations in this article are from the Museum of Science and Industry, Chicago, Ill.

GRAIN-MILLING DEVICES DEVELOPED ALONG THREE MAIN LINES

The three lines along which the milling device has developed are those of pounding or impact crushing, pressing or pressure crushing, and last and most important, rubbing, involving a combination of shearing and pressure crushing. Of these, pounding is the oldest, dating from the Old Stone Age. The distinguishing feature of this kind of grinding is the sudden application of force—as contrasted with the slower pressing—

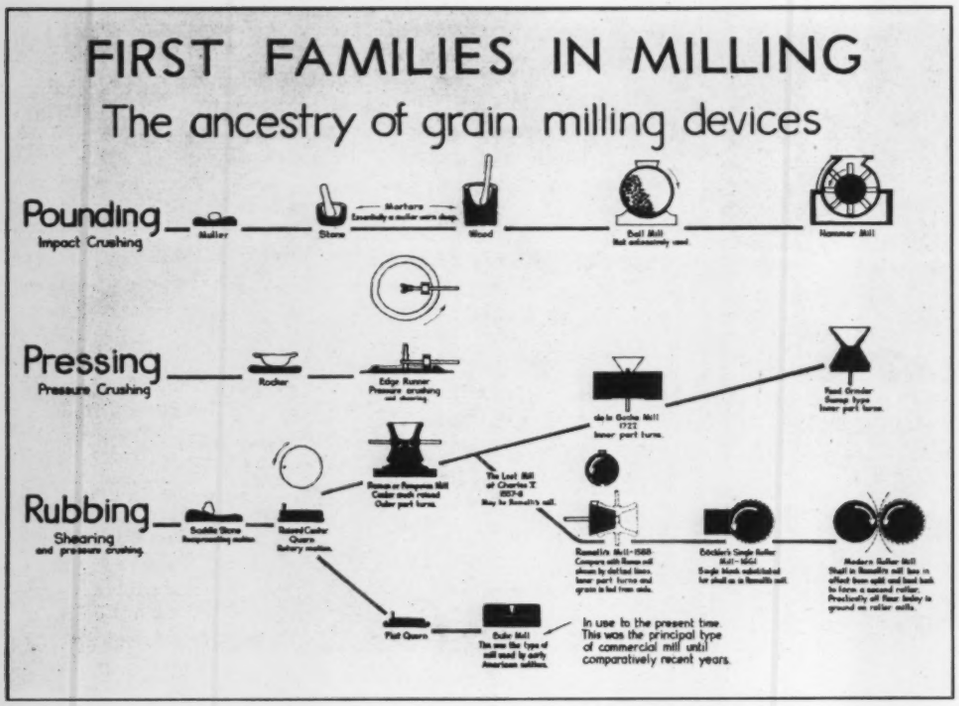

FIG. 1 THIS CHART, WHICH OUTLINES GRAPHICALLY THE DEVELOPMENT OF THE PRINCIPAL TYPES OF MILLING DEVICES, WAS PREPARED BY THE AUTHOR IN CONNECTION WITH THE MILLING EXHIBITS AT THE MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, ILL.

by which the grain is ruptured and reduced to flour or meal. We may say with some certainty that the first milling device—if we except the human molar—was a form of pounding mill which is generally called a muller. In this mill there is a slight hollow in the stone, Fig. 2, which may or may not be portable, into which the grain is put and crushed with a handstone. Doubtless the origin of this simple device was the use of a handstone to crush seeds on a flat rock. Perhaps continued pounding wore a small cavity and man learned that the grain in this hollow scattered less under the impact than on a flat stone, and he continued to make mullers in this form. At any rate, it is found among the artifacts of the Old Stone Age. It has been found in Asia, Europe, Africa, and the Americas, and is used to grind pigments for war paints as well as grain. Originally the under stone was often a large boulder or ledge of stone, but eventually man learned the advantage of making it smaller that he might more readily take it with him as he moved about.

From the muller it is but one step to the mortar which is essentially a muller worn deep. It seems so reasonable that continued operation of a muller—particularly in soft stone—would naturally result in a gradually deepening cavity that we may accept this, in the absence of written records, as the origin of the mortar. As the cavity deepened, the handstone lengthened until it became a pestle as we know it. The mortar was more difficult to make than a muller and, because of its size, more difficult to transport, but its greater capacity and convenience of operation commended it. Stone and wood were common materials for making mortars in most if not all parts of the world. Americans are familiar with not only the stone mortars of the southwestern Indians but also the wooden mortars used by the Indians of the wooded sections and by the early white settlers. With the latter it was a stop gap for producing meal or flour until they could erect some form of a buhr mill.

The mortar has been used throughout the world and is still to be found in use among the more primitive peoples. In a simple life where the demands are not great, it serves a useful purpose despite its obvious limitations of output. It may be interesting to point out the long-continued use of the mortar and pestle—the symbol of the apothecary—in the drug trade and of the gold stamp, which is only gradually being replaced for the crushing of ore.

But this line, so early founded, soon reached its apparent peak in the mortar and ceased to develop in the milling field. The mortar reached its limit of perfection and marked time while its rival, the saddle stone, and its descendants, which used rubbing or shearing and pressure crushing, rose to predominance unchallenged until recently and still unshaken in the production of flour.

RECENT REVIVAL OF INTEREST IN IMPACT CRUSHERS

But the family of impact crushers, despite its seeming limitations, had possibilities which have recently been brought out. From the standpoint of the flour miller, the lesser of these examples is the ball mill which had its origin in other industries. Rotating cylindrical drums of wood or thin plates of metal in which were placed iron balls were apparently first used in a powder mill in France and soon in indigo, cacao, and gypsum mills. From the middle of the 19th century, they were used in ore grinding and now are extensively used in metallurgy and cement manufacture. About sixty years ago they were used in flour milling but were abandoned until recent years when they have again been tried out experimentally.

The device has been found to have some definite limitations when applied to the reduction of a soft material carrying the percentage of moisture found in wheat. Under the impact of the balls, particularly in large, rapidly revolving cylinders, the material tends to become a sticky mass through which it is difficult to force enough air to take out the fine material as produced without blowing over material not yet ready to go. Further experiments with the ball mill and the rod mill are yet to be made before their efficiency as primary grinders is established but a limited use of the principle is being made today in a variation of the middlings purifier. A small cylinder is rotated slowly so that the balls tumble gently down on the middlings and wear away the bran particles without forming a sticky mass which prevents the bran from being taken off by an air stream.

But it is another relative, the hammer mill, which has revived the family fortune in recent years, particularly in the feed-grinding industry. The modern hammer mill with its rotating arms which strike the grain and crush it so that the ground material falls through a screen needs no further description. It

is worth noting that the hammer mill has, in recent years, largely replaced the sweep type of farm feed grinder which was such a common sight on our farms not many years ago. This sweep mill—see the chart—is a declining member of one branch of the rubbing family, which after a long dominance sees its reign in the feed kingdom ended by a machine employing the principle of impact crushing which dates from the use of the simple muller.

FIG. 2 MILLS ON EXHIBIT AT THE MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, ILL.
(Roman mill on left. Wood mortar on right.)

THE ANCIENT SADDLE STONE GROUND BY RUBBING

In the New Stone Age the dynasty of the rubbing family was founded by the saddle stone, examples of which are shown in Figs. 4, 5, and 6. In this mill the pounding action of the muller was replaced by a reciprocating motion. The name is derived from the similarity between the usual shape and that of a saddle. The curved surface usually slopes down and away from the operator who grinds the grain by rubbing back and forth with a handstone. They may or may not be worn down to form a trough. Sometimes, as in the case of the stone from Tell Beit Mirsim in Palestine (about 1000 to 700 B.C.) shown in Figs. 4 and 5, they are flat but this shape is not usual. In Central America and Mexico they have short legs. In all cases, however, the principle is the same. The action is that of shearing or abrasion with some pressure crushing due to the weight of the stone or the pressure applied by the operator. Throughout the whole line of rubbing milling devices the same distinguishing shearing action is found with a varying amount of pressure crushing.

The saddle stone was an important mill throughout the classical ancient world and is the one referred to in Exodus 11: 5, "And all the first-born in the land of Egypt shall die, from the first-born of the Pharaoh that sitteth upon his throne, even unto the first-born of the maidservant that is behind the mill . . ." It was on such a mill that the patriarch Abraham directed Sarah to "make ready quickly three measures of fine meal" from which to make cakes for the angels, or that Moses referred to when he forbade the taking of either the nether or the upper millstone to pledge because in so doing a man took another's life in pledge. It was widespread also in the Americas and at a much later time in darkest Africa. They are usually light and easily carried about. Its well-nigh universal use among primitive peoples is evidence that despite its limitations it served the people well.

DEVELOPMENT OF THE QUERN FROM THE SADDLE STONE

We ordinarily think of the Romans as lawgivers and builders but they also made some notable contributions to milling technology. They took the next step beyond the saddle stone when they devised the raised-center quern about the third century before Christ. They used an upper and a lower stone but with a rotary rather than a reciprocating movement. One or two operators, commonly women, sat beside the mill and turned the upper stone round and round while they fed in the grain at the center. The grain as it was reduced traveled around and outward and dropped as flour from the edge of the stone. Here was a primitive device that had extraordinary possibilities of development. Indeed, from it was to come the buhr mill, the sweep type of feed grinder, and the modern roller mill, all apparently so dissimilar. Its shearing action, continuous rotary motion, and a steady flow of material with gradual reduction were the elements which led to its development to a dominant position.

The first querns were made with raised centers in order, as thought necessary, to facilitate the outward flow of material and to insure an adequate capacity. It was found, however, that the mill would grind with or without this raised center; and as a result there branched from this point two lines of development.

In one variation of this device the stones were made flat and the mill became a flat quern. While it was found that the raised center was not essential in the quern, it was learned at least as early as Roman Briton times that these millstones did better work if they had grooves, the forerunners of the elaborate dressing of later times, to facilitate the working of the fine material outward and increase the capacity of the mill. Practically all querns were made without grooves, however. The flat quern came into common use in Europe, Asia, and northern Africa, but not among the Australians, the natives of central or southern Africa or the American Indians whose milling never advanced beyond the saddle-stone or metate stage. It was such a mill that Christ had reference to in the warning that "Two women shall be grinding at the mill; the one shall be taken and the other left." (Matthew 24: 41.)

Some querns were made light, merely for cracking lentils, Figs. 7 and 8, while most of them were heavy enough to grind

flour effectually As long as the power was furnished by a person sitting beside it the mill must perforce remain small. But as water and wind wheels were developed during the Middle Ages the querns were enlarged until they became what we know as the buhr mills, from two to six feet in diameter. This was the mill which was common in western Europe from feudal days (during which times the barons and bishops forced the peasants to give up the quern in order to swell their own revenues as mill owners), until a comparatively few years ago and which we provincially think of as a colonial mill. Our early settlers ground their meal and flour first by a mortar but as soon as possible by a buhr mill driven commonly by a water wheel but occasionally by oxen. This was the mill which was used from the rise of commercial milling both in Europe and America until the time of the extensive use of the roller mill about 1870 to 1880. It was not until the latter year that in the famous Washburn A mill in Minneapolis the stands of rolls replaced the stone buhrs which were, in a technical sense, only three generations removed from the saddle stone. For two thousand years the buhr mill was the standard milling device of advanced peoples.

DEVELOPMENT OF THE ROMAN MILL FROM THE QUERN

We must now retrace our steps to the parting of the ways at the raised-center quern and it will be well to refer to the chart again. While the raised center was discarded by one line—that leading to the buhr mill which was for centuries the most successful—it was retained and accentuated in the Roman or Pompeian mill which the Romans invented about 200 B.C. and which was destined to have a notable development. In the Roman mill—many of which were found when the buried cities of Pompeii and Herculaneum were uncovered—the center was much raised until it took a high conical shape. The upper stone was likewise transformed until it became a shell to which was added a stone top which served as a hopper as shown at the extreme left in Fig. 2. As the grain moved downward it was gradually reduced between the converging stones. As in the case of the quern the upper and outer part, known as the catillus, turned. In the case of the smaller mills the slaves furnished the motive power, but in the large mills, known as mola asinara, the power was supplied by beasts.

For a thousand years after the fall of the Roman Empire there was but little change in the technique of milling except the enlargement of the buhr mill, belonging to another branch of the rubbing family as previously described. It is difficult if not impossible to say how much those who developed the later mills drew upon the Roman mill. From an analysis of the elements involved, there appear two diverging lines of development, one leading to the sweep type of feed grinder which has been mentioned before and the other to the modern roller mill.

FIG. 3 A COLLECTION OF MILLING DEVICES IN THE MUSEUM OF SCIENCE AND INDUSTRY

(On the table, from left to right, are a flat saddle stone from Tell Beit Mirsim, Palestine, 1000 to 700 B.C., an iron mortar and pestle, a flat quern, and a coffee mortar. The large mortar below is for grinding corn, while that on the right is a rice mortar.)

FIG. 4 FLAT SADDLE STONE FROM TELL BEIT MIRSIM, PALESTINE, 1000 TO 700 B.C.

FIG. 5 DEMONSTRATING HOW THE FLAT SADDLE STONE SHOWN IN FIG. 4 WAS USED

FIG. 6 USUAL FORM OF NORTH AMERICAN INDIAN SADDLE STONE

FIG. 7 FLAT QUERN FOR CRACKING LENTILS

THE LOST MILL OF CHARLES V

At this point we are confronted with an enigma, that of the lost mill of Charles V. It may be described as a lost mill because our information about it is limited and we cannot be certain of its form. We know, however, that when Charles V abdicated the throne of Spain in 1557 he retired to the monastery of San Geronimo at Juste, Spain, where, during the winter of 1557–1558, he and a mechanic, Iuanelo Turriano, made an iron mill. We are told that this mill was so small that a monk could carry it under his arm and with it a man could grind as much flour as was necessary for eight men. Truly this was a weak beginning —undoubtedly a buhr mill of the day could produce much more—but if those who came after Charles followed its pattern it deserves an honored place as one of the steps leading to the roller mill and perhaps to the sweep-type of grinder.

From the description which we have of this mill there is much reason to believe that this lost mill is none other than that described in 1588 by Ramelli in his book, "Le Diverse et Artificiose Machine." No one pretends that Ramelli was the inventor of the many devices pictured and described in this valuable work. Ramelli, like Besson, Böckler, and others, gathered illustrations wherever he could find them and published them without acknowledgment. Ramelli's mill, as seen in Fig. 12, consisted of a horizontal iron core in the shape of the frustum of a cone and an iron shell of the same shape. Grain was fed in at the side and ground as the corrugated core was turned inside the shell which was likewise corrugated. This mill, which seems to fit the description of that of Charles V, has some striking resemblances to the Roman mill. Note on the chart (Fig. 1) the dotted outline of the Roman mill superimposed upon the Ramelli mill. Turn the Roman mill on its side, cut away the hopper (indeed, a perfect specimen of the Roman mill found in Britain did not have this stone hopper) and turn the inner rather than the outer part and you have the Ramelli mill in principle. We cannot say, however, that the inventor of this mill, perhaps Charles V, adapted the features of the Roman mill. We can only suggest the points of similarity.

Incidentally, a mill similar to Ramelli, sold in the United States in 1859. It had a fluted horizontal cylinder of white cast iron operating in a case which had a fluted concave below and vibrating flanges above.

In the following century, in 1661, Böckler published in his book, "Theatrum Machinarum Novum," a collection of plates and descriptions of mechanical devices, in which was shown a mill, Fig. 11, which has a distinct similarity to Ramelli's mill in one important particular. The inventor may have concluded that, although the grain might be carried round and round in that mill, a part of the cone was not being fully used and might be eliminated. In any event instead of a shell, as in the Ramelli mill, a concave block of stone was used against which a stone cylinder ground the grain, both shearing and crushing it as it worked down through the narrowing space. The grinding action must now take place as the grain passes a few inches of the stone-block face.

FIG. 8 LIGHT QUERN USED RECENTLY IN PALESTINE FOR CRACKING LENTILS
(The upper stone is here raised to show the flat surface, the center pin, and the hole through which lentils are fed to the mill.)

FIG. 9 FLAT QUERN FROM PALESTINE USED FOR GRINDING WHEAT AND EQUIPPED WITH A CLAY TROUGH FOR CATCHING THE FLOUR

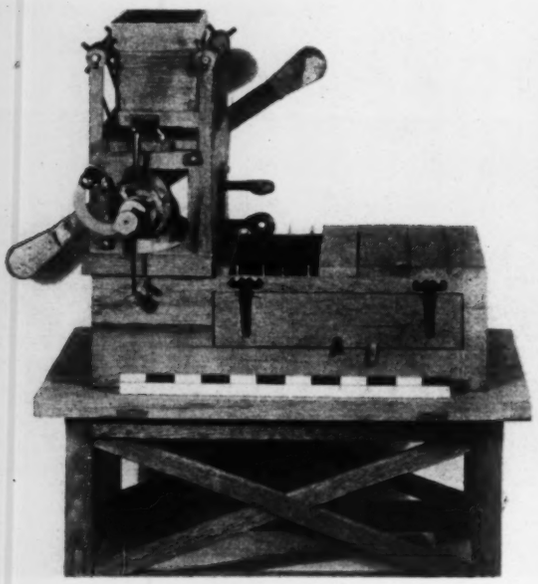

FIG. 10 QUARTER SIZE MODEL OF BOCKLER SINGLE ROLLER MILL MADE FROM THE ILLUSTRATION IN HIS BOOK—SEE FIG. 11
(A portion of the side of the mill has been removed to show the roller and block.)

THE EVOLUTION OF THE ROLLER MILL

Now we come to the roller mill as we know it. In the evolution which we have traced, the center of the quern has, in effect, been pulled up and through the upper stone until it has become a cylinder, and the upper stone has now become a shell. Grain is ground between these two parts due to the differential between their speeds. The fact that one part remains stationary does not alter that fact. Suppose that one splits the shell of the Ramelli mill (represented in part by the concave block of Böckler) and bends it back as indicated on the chart to form a second cylinder. What was before the inner grinding surface of a shell now becomes the outer grinding surface of a second cylinder. In this case the output of the mill is increased by running the two cylinders at different speeds. The varying corrugations of the rolls and running of these rolls sharp to dull, dull to dull, etc., are details which need not concern us here. Thus from the saddle stone through the raised-center quern, the Roman mill, the Ramelli mill, the Böckler mill, and the modern roller mill there seems to run a thread of relationship.

We have traced one of the two lines which from a technical standpoint seem to branch from the Roman mill. The other

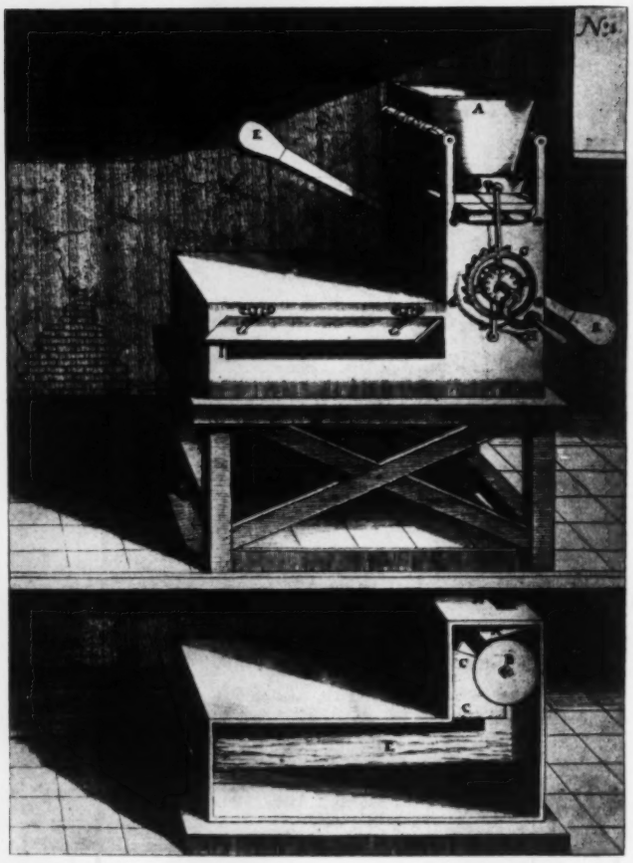

FIG. 11 SINGLE-ROLLER MILL FROM BOCKLER'S *Theatrum Machinarum Novum*, PUBLISHED IN 1661

is somewhat less important but it raises an interesting question. The de la Gache mill of 1722 ("Machines approuvées par l'Academie Royale des Sciences," Vol. 4) consisted of a vertical roughened iron frustum of a cone turning in a corrugated-iron shell with a metal hopper as shown in Fig. 13. It is very much like the Roman mill in form but in this case the inner rather than the outer part turns. On the other hand, it is essentially the Ramelli mill raised to a vertical position with a hopper added. Perhaps the former derivation is more logical but it is quite possible that it may have come from the mill of Charles V or Ramelli. Any statement would be pure conjecture and both views might be held with much reason. The principle has been used in the common sweep-type feed grinder, which have been referred to as having given way to the hammer mill. This branch of the family has not been an important one.

THE CHILEAN PRESSURE CRUSHING MILL

The third family of milling devices—not numerous or well

defined—may be distinguished, for the want of a better name, by the term, pressing, since their action involves pressure not applied sharply as in impact crushing but more slowly so that the grain is ruptured by mashing rather than by shearing. The simplest mill of this type is the rocker, a specimen of which was found by Flinders Petrie in Egypt and which he thought to be a form of the saddle stone. Bennet and Elton considered it a very curious implement and, if a grain stone, quite unique. Its use as a grain mill seems to be confirmed, however, by the use today among the Indians of the Peruvian highlands of a grinding stone which is very similar in shape. There the operator places grain, in this case maize, on a flat rock and reduces it to meal by rocking the stone back and forth, stopping occasionally to rake together the scattering grain and meal. It is possible that there is a slight shearing action if the stone is twisted as it is rocked but this does not seem to be the case.

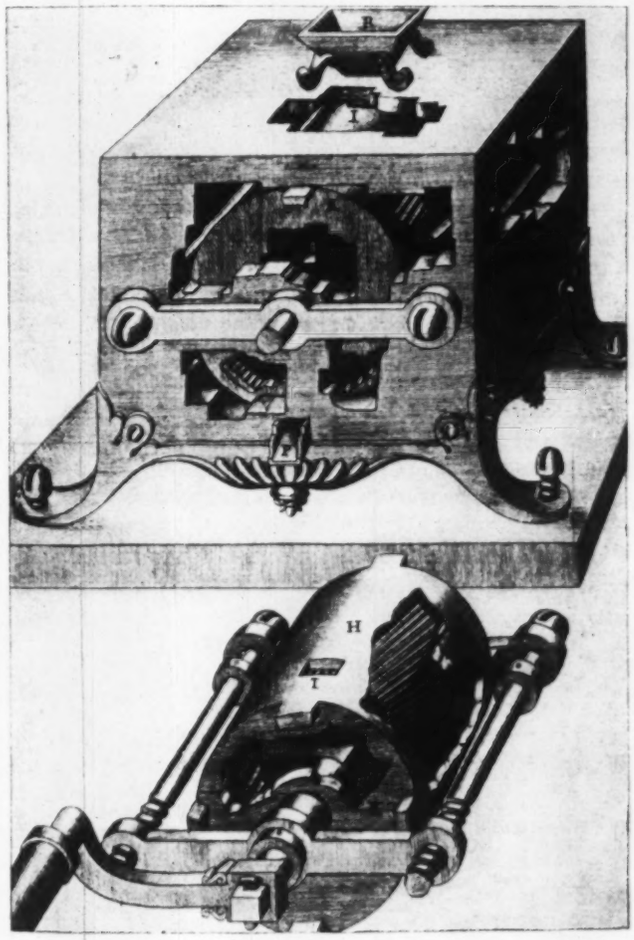

FIG. 12 THE RAMELLI MILL FROM AN ILLUSTRATION IN *Le Diverse et Artificiose Machine* PUBLISHED IN 1588

The edge runner or Chile mill, Fig. 14, has been widely used for many purposes, one of the lesser ones being for flour milling. It consists of a cylinder, usually of stone, large or small, narrow or wide, placed on a shaft and rolled about a pivot. Here the action is both pressure crushing and shearing. Where the stone is narrow and large in diameter and turning upon a relatively large radius there is a minimum of side slipping and shearing but where the stone is small and wide and close to the pivot it will necessarily slip a great deal and in doing so shear the grain as well as mash it.

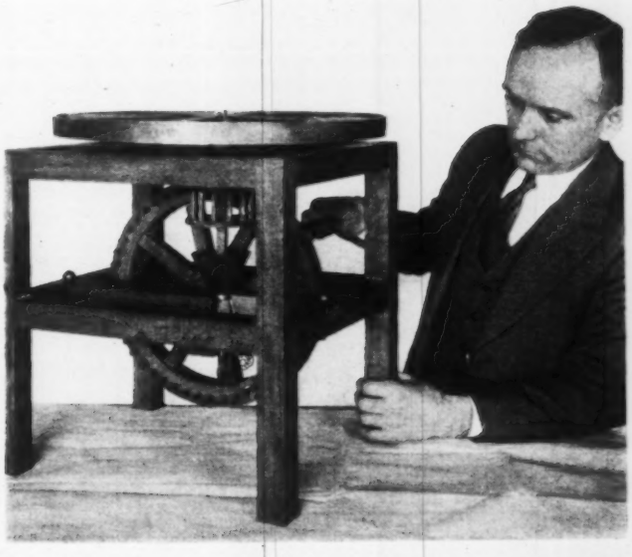

FIG. 13 QUARTER-SIZE MODEL OF THE DE LA GACHE MILL OF 1722 AT THE MUSEUM OF SCIENCE AND INDUSTRY, CHICAGO, ILL. (Note cutaway section showing the vertical grinding cone.)

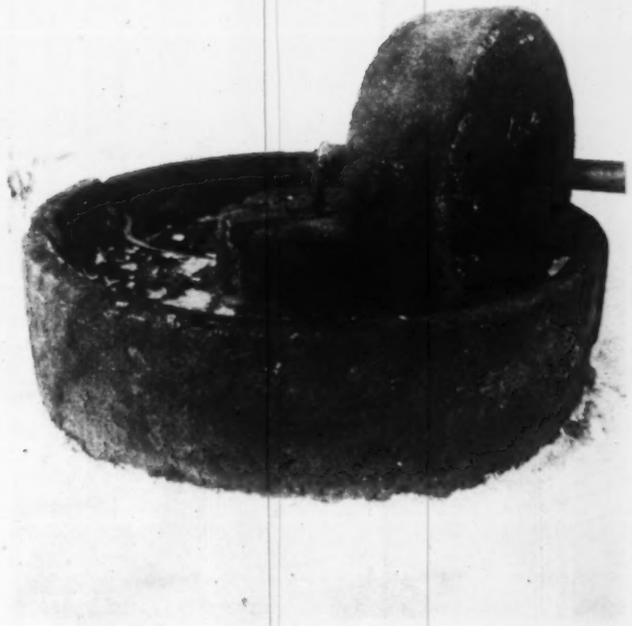

FIG. 14 AN EDGE RUNNER MILL, FREQUENTLY CALLED THE CHILEAN MILL, THE USE OF WHICH FOR FLOUR MILLING HAS BEEN LIMITED

Thus has man developed and elaborated this very important device, the mill. In some cases the adaptation has doubtless been made consciously, whether or not we can prove the point, while in others the mechanical experience of the race, diffused and widely varying, has been crystallized into a new form of mill the ancestry of which may not be entirely clear.

THERMODYNAMIC PROPERTIES *of* COMPRESSED LIQUID WATER

By C. HAROLD BERRY

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WITH steam pressures rising to higher levels in modern power-plant practice, it is becoming increasingly important to consider the effect of pressure upon the properties of the boiler feedwater and to compute the work of the feed pump and the resulting increase in enthalpy of the water, which reduces the heat transfer required in the boiler. Fundamental data of this nature have been published[1] by J. H. Keenan in a skeleton table in English units with charts in metric units. In Figs. 1, 2, and 3 the author has plotted and cross-faired Professor Keenan's data and believes that these three figures provide convenient solutions for any problem that is likely to arise in practice.

Fig. 1 gives the value of the numerical difference between the enthalpy of the liquid and its temperature, this difference being a function of both temperature and pressure. When the pressure and temperature are observed directly, it is possible to find from Fig. 1 the enthalpy of the liquid by reading a single value D from the chart and subtracting it from, or adding it to, the observed temperature. At lower temperatures the enthalpy may be found to within 0.1 Btu per lb if the temperature has been read to 0.1 F and a full-size chart is used. At higher temperatures, where such precise measurements probably are rare, values of the difference to the nearest unit only can be obtained from the chart. (One section of Fig. 1 appears below and the other on the following page.)

Fig. 2 gives the temperature rise in isentropic compression. The temperature rise above the value for saturated liquid at the same entropy is indicated by the symbol Δt_s. The temperature rise during isentropic compression equals the difference between two values of Δt_s at the same entropy, and can be expressed as

$$t_2 - t_1 = (t_2 - t_f) - (t_1 - t_f) = \Delta t_{s2} - \Delta t_{s1}$$

all values used in this equation being obtained at the same entropy. The isotherms on this chart serve to locate the initial points only. The final point is located by the given final pressure and the entropy of the initial point. Linear interpolation between adjacent curves is sufficiently accurate when a full-size chart is used.

Fig. 3 gives the work of isentropic compression. The excess of enthalpy above the value for saturated liquid at the same entropy is indicated by the symbol Δh_s. The work of isentropic steady-flow compression equals the difference between two values of Δh_s at the same entropy, and can be expressed as

$$w_{12} = h_2 - h_1 = (h_2 - h_f) - (h_1 - h_f) = \Delta h_{s2} - \Delta h_{s1}$$

all values used in the equation being obtained at the same

[1] "Thermal Properties of Compressed Liquid Water," by J. H. Keenan, MECHANICAL ENGINEERING, vol. 53, no. 2, February, 1931, pp. 127–131.

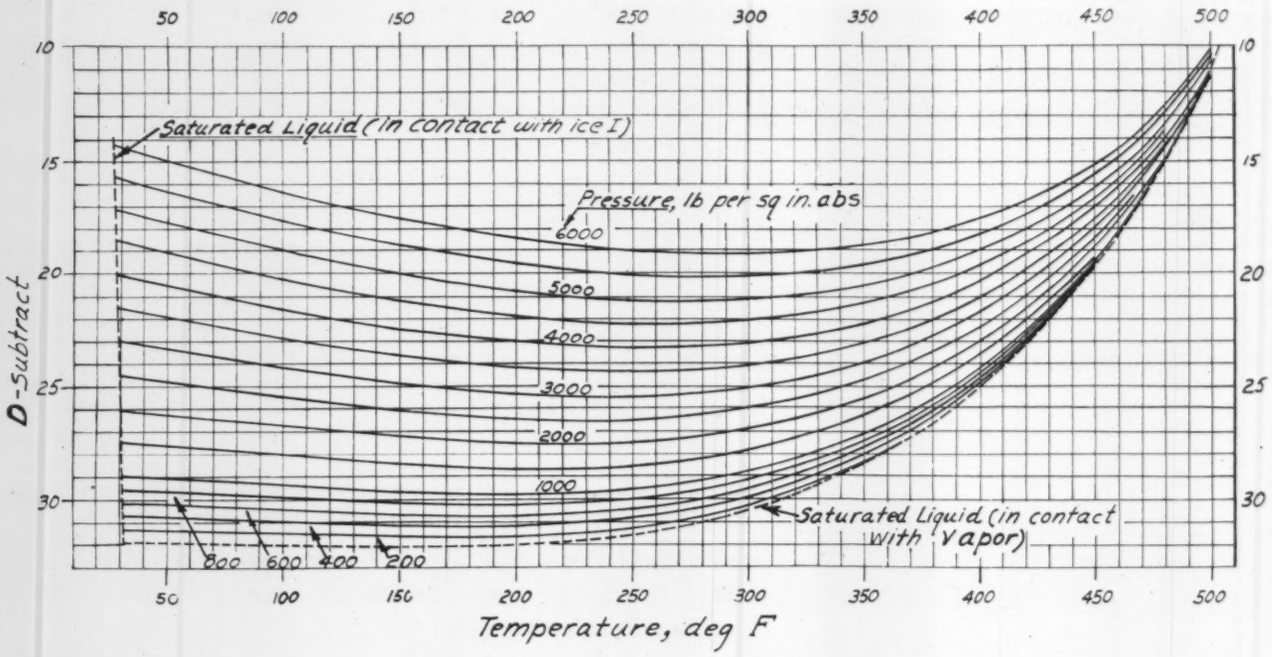

FIG. 1 ENTHALPY FROM PRESSURE AND TEMPERATURE

entropy. The isotherms on this chart serve to locate the initial point only. The chart in Fig. 3 must not be used to find the temperature rise attending compression, reference to Fig. 2 being necessary for this purpose. Linear interpolation between adjacent curves is sufficiently accurate when a full-size chart is used.

The use of Fig. 1 may be illustrated by assuming that a pump receives water at a pressure of 400 lb per sq in. and a temperature of 390 F, and delivers it at a pressure of 5500 lb per sq in. and a temperature of 402 F. From a full-size chart of Fig. 1, the corresponding values of *D* are found to be 25.6 and 18.2, respectively, and both values are negative. Accordingly, the enthalpy of the liquid at the pump suction is 390 — 25.6 =

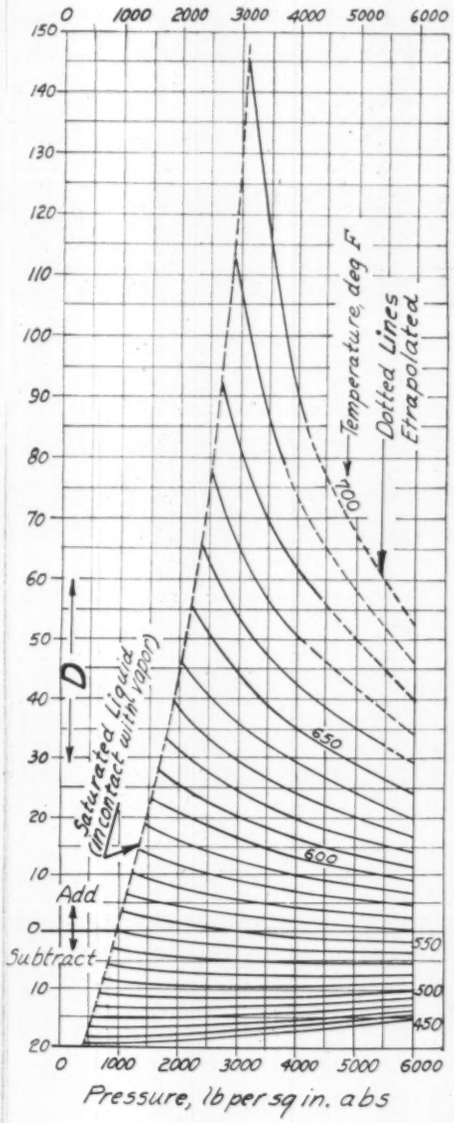

FIG. 1 (CONTINUED FROM PRECEDING PAGE)

364.4 Btu per lb, and at discharge it is 402 — 18.2 = 383.8 Btu per lb. The work that has been done upon the water by the pump is equal to the rise in enthalpy of the water, or 383.8 — 364.4 = 19.4 Btu per lb. These values assume that the temperatures have been observed to 0.1 F. If the observations were less precise, say to the nearest degree, the result would have been 384 — 364 = 20 Btu per lb. The work done upon the water (analogous to the water horsepower) can be compared with the total work delivered to the pump, whereupon the pump frictional losses can be estimated.

Fig. 2 gives the temperature rise accompanying the compression of water in an ideal pump, in which the compression is isentropic, that is, adiabatic and reversible. Pump losses are zero. Using this chart in connection with the problem in the preceding paragraph, the initial point corresponding to the suction pressure of 400 lb per sq in. and the temperature of 390 F is located. At this point on a full-size chart it is noted that the temperature of the water is 0.4 F above the temperature of saturated liquid at the same entropy (0.554). Following the constant-entropy line vertically from this point to the final pressure of 5500 lb per sq in., a temperature excess of 10.3 F is read. Accordingly, if this operation had been conducted in an ideal pump, the temperature of the water would have risen 10.3 — 0.4 = 9.9 F, instead of the observed rise of 12 F (in at 390, out at 402). The additional rise of 2.1 F in the real pump is due to the dissipation of work through fluid friction.

The work done upon the water in the ideal pump can be obtained from Fig. 3. Locating on this figure the initial point where the suction pressure is 400 lb per sq in. and the temperature is 390 F, it is noted that the enthalpy of the liquid is 0.6 Btu per lb above the enthalpy of saturated liquid at the same entropy (0.554), as before. Following the constant-entropy line vertically from this point the final pressure of 5500 lb per sq in., an enthalpy excess of 17.9 Btu per lb is observed. Accordingly, in the ideal pump the work delivered to the water (and to the pump) would be 17.9 — 0.6 = 17.3 Btu per lb. The real pump, as found previously, delivered 19.4 Btu per lb to the water. The internal losses of the pump that appear as reheat in the fluid must then be 19.4 — 17.3 = 2.1 Btu per lb. That this is numerically equal to the excess temperature rise in the real pump compared with the ideal merely reflects the fact that in this region the specific heat of water differs but little from unity.

The numerical values used in these examples are not to be taken as typical of what may be expected in practice. They have been chosen arbitrarily solely to illustrate the use of the charts in Figs. 1, 2, and 3.

Fig. 2 may be regarded as a modified temperature-entropy diagram in which the usual liquid saturation line has been made to coincide with the horizontal axis, with the lines for higher pressures following the saturation line at their proper intervals. The inflected curves in the upper region simply reflect the fact that in the temperature-entropy diagram the supercritical constant-pressure lines proceed upward while the saturation curve turns downward to form the top of the dome at the critical point.

Similarly, Fig. 3 is a modified Mollier enthalpy-entropy diagram with its liquid line made to coincide with the entropy axis. In view of these distortions, care must be taken to use these two diagrams to obtain only the difference between two values lying on the same vertical constant-entropy line as illustrated in the preceding examples. The difference between values situated otherwise is without significance, because the value of any point gives the excess of temperature or enthalpy above the value for saturated liquid at the same entropy. Therefore, points on different vertical constant-entropy lines have values that are referred to different datum points, and hence cannot properly be used together.

The charts in Figs. 1, 2, and 3 have been intercompared and their readings give values that check satisfactorily, although exact identity of results could hardly be expected. It is interesting to compare the values of work obtained from Fig. 3

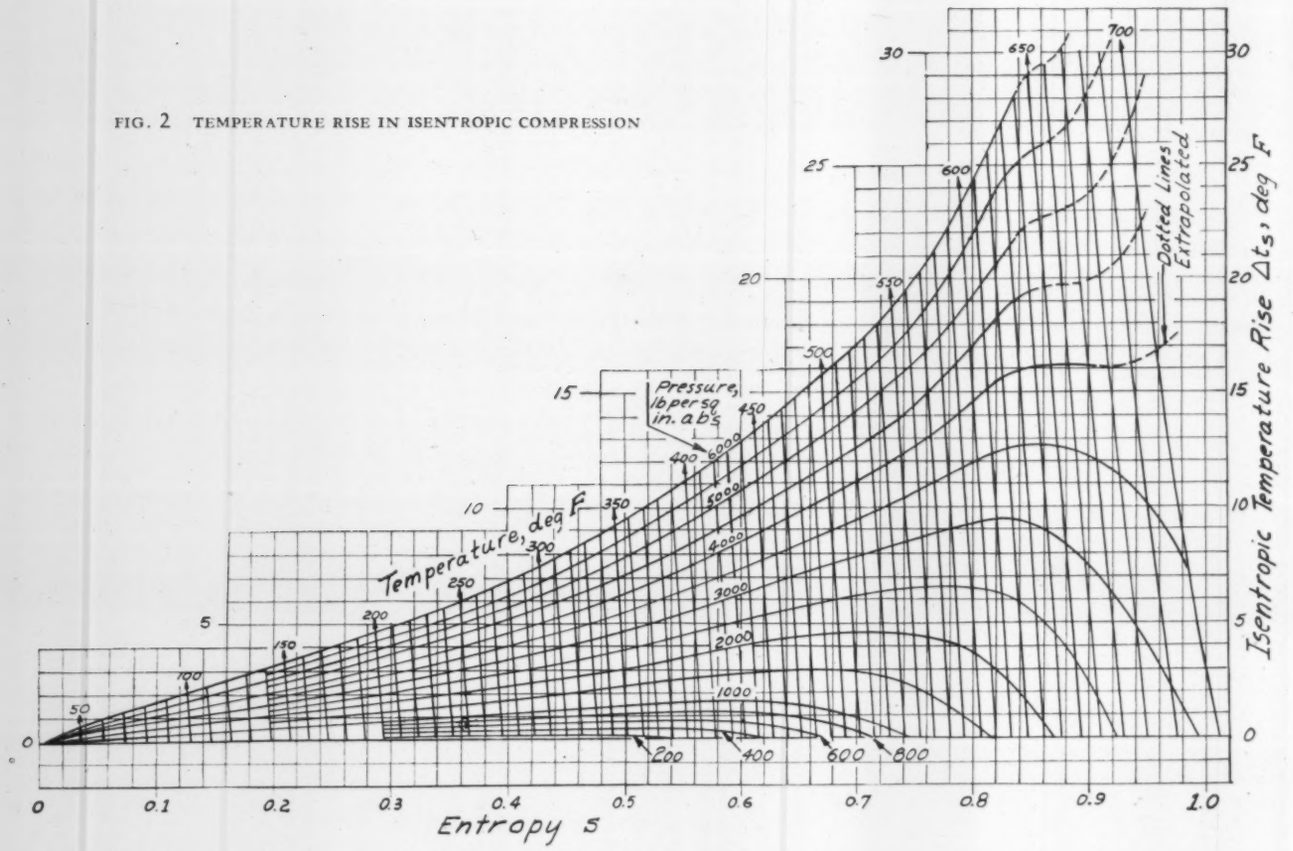
Pressure, lb per sq in. abs
Temperature, deg F
Dotted Lines Extrapolated
Isentropic Temperature Rise Δt_s, deg F
Entropy s

FIG. 2 TEMPERATURE RISE IN ISENTROPIC COMPRESSION

with the approximate values computed on the assumption of invariable volume during compression, namely, work = (144/788) v (p_2 — p_1). Approximately, it can be said that when the final pressure is not greater than 3000 lb per sq in., the results by the two methods will agree within 0.1 Btu per lb, and that when the final pressure is not over 5000 lb per sq in., the results will agree within 0.2 Btu per lb, except at higher entropies, where the error increases rapidly. Inasmuch as Fig. 3 seems to give a more dependable result with less labor, it is unnecessary to consider further the use of the constant-volume formulation. Blue prints of full-size charts from which diagrams were drawn may be obtained from the author.

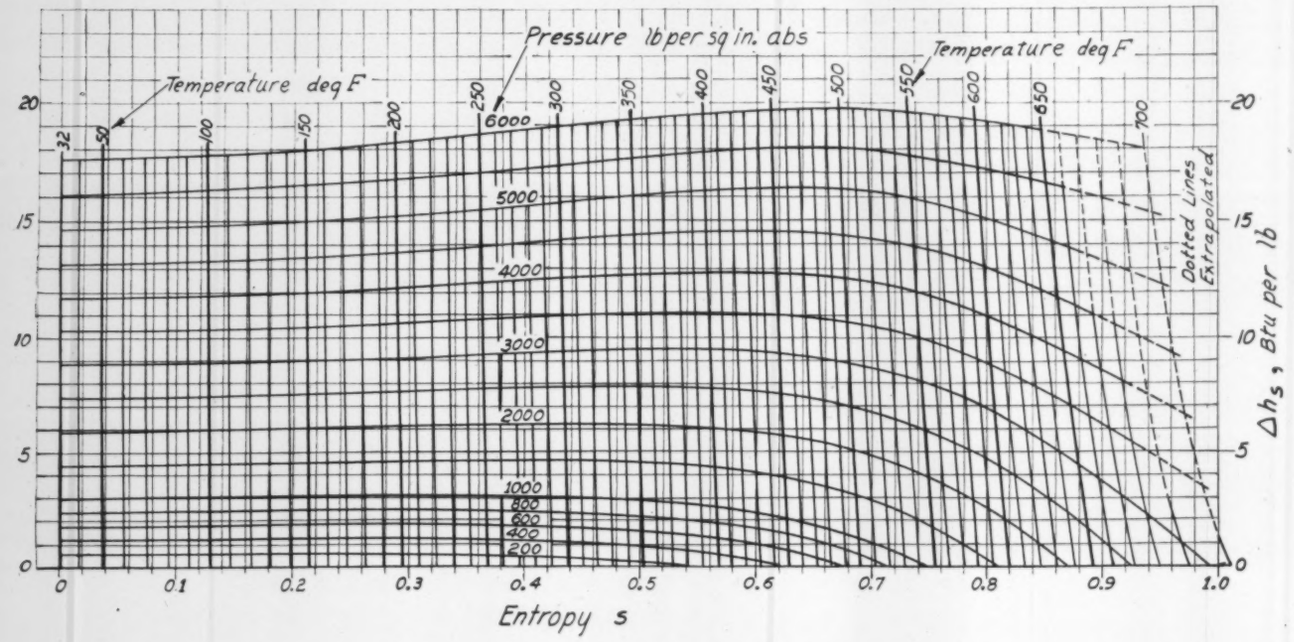

FIG. 3 WORK OF ISENTROPIC COMPRESSION

METALLIC HEAT INSULATION

By J. T. NICHOLS

AMERICAN SHEET AND TIN PLATE CO., PITTSBURGH, PA.

THE USE of metal sheets arranged with a definite space relationship has recently attracted considerable attention as a means of heat insulation. In Germany, Schmidt and Dyckerhoff reasoned that sheets of bright metal would be suitable for reflecting radiant energy, which comprises a large proportion of heat transfer at relatively low temperatures, and therefore their British patent 266,177, dated February 24, 1927, describing the use of such sheets for insulating purposes, emphasized the use of bright metallic surfaces. Apparently it never occurred to Schmidt and Dyckerhoff that surfaces which are relatively poor reflectors in the visible region may be good reflectors of the longer wave lengths which have the greatest effect in transferring heat at the lower temperatures. It is a fact that we are accustomed to viewing colored surfaces possessing highly selective characteristics of reflection in the visible region, and, while every one realizes that selective reflection is common, it is generally believed that metal surfaces, to be used successfully as heat insulators, ought to be good reflectors in the visible region. Possibly it is because of this fact that it remained for LeGrand (U. S. patent 1,910,703) to propose the use of common metals, such as steel, for this purpose. The curves in Fig. 1 represent the reflectivities of several of the common metals. The data from which these curves are plotted were found in the International Critical Tables and are based on the work of Coblenz and others. It will be noted that many of these metals are characterized by relatively low reflectivities in the visible range and relatively high reflectivities in the longer wave lengths.

The intensity of radiant energy I, at wave length λ, from a hot body of absolute temperature t, having an emissivity at that wave length of E, as set forth by Wein, is

$$I = C_1 E \lambda^{-5} e^{(-C_2/\lambda t)}$$

It is apparent that the maximum value of I is a function of the temperature t and, moreover, that this maximum occurs at increasing values of wave length λ as the temperature is lowered. A simple integrating type of reflectometer which can readily be demonstrated has been prepared to illustrate how this affects the transmission of heat. The instrument, Fig. 2, consists of a small electric heater which is operated at a temperature of about 300 F, a sample surface arranged to reflect heat into a thermopile, and a d'Arsonval galvanometer connected so as to indicate the voltage generated by the thermopile. This instrument provides a means for comparing the relative value of the reflecting powers of various surfaces with the total energy radiated by the electric heater. The relative reflectivities of several surfaces, based on unity as the value for commercial full-finished black plate, are given in Table 1. It is apparent that most clean metals reflect sufficient energy in those wave lengths to be used for insulating purposes.

Considerable attention has been devoted to the transfer of heat by means of radiated energy because this form of transfer predominates in the more common problems. To illustrate, the total amount of heat transferred may be calculated for a typical domestic-refrigerator cabinet wall, consisting of two sheets of steel $2\frac{1}{2}$ in. apart, between which are supported four thin sheet-steel radiation shields held in a suitable frame so that the spaces between the sheets may be sealed from the outer atmosphere and from each other. If the outer side of the cabinet wall is held at 100 F and the inner side at 40 F, the heat transferred by radiation will be 57.4 Btu multiplied by the emissivity of the steel sheets. The heat transferred by convection through films of air averaging $\frac{1}{2}$ in. in thickness is small at these temperatures. By direct conduction, about 4 Btu per hr per sq ft will be transferred. Such a refrigerator-cabinet wall, using commercial full-finished black-plate radiation shields, has a heat-transfer coefficient of about 0.25 Btu per hr per deg per sq ft per in.

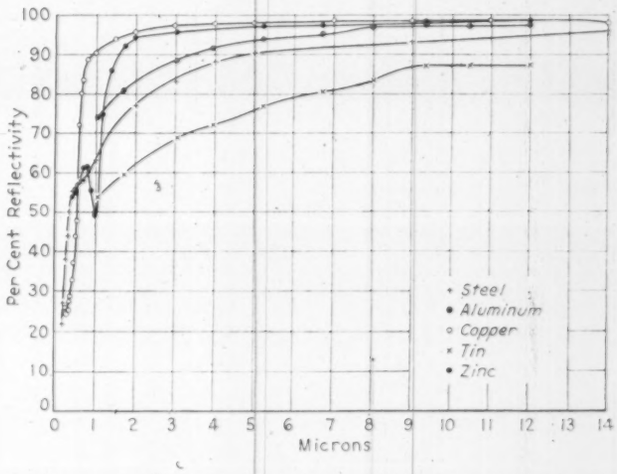

FIG. 1 RELATIVE REFLECTIVITIES OF SEVERAL COMMON METALS

It may be of interest to review, briefly, some of the tests which have been made with sheet-steel insulation to establish what rate of heat transfer can be expected with practical forms of construction.

TABLE 1 RELATIVE REFLECTIVITIES

(Total radiation from hot ring at about 300 F)

	Sheet Steel	
1	Full-finished black plate	1.00
2	Hot-rolled and annealed	1.00
3	Hot-rolled, pickled, and annealed	0.91
4	Hot-rolled, pickled, annealed, one-pass cold-rolled	0.99
5	Zinc coated (dull)	0.99
6	Galvanized	0.98
7	Galvannealed	0.64
8	Tin plate	1.02
9	18-8 chromium nickel	0.92
10	Cold-rolled strip (bright)	1.02
11	Terne coated	0.99
	Other Materials	
1	Copper	0.97
2	Aluminum sheet	1.01
3	Aluminum (sand-blasted)	0.50
4	Black paper	0.23
5	White paper	0.28

Contributed by the Air Conditioning Committee for presentation at a meeting, New York, N. Y., Oct. 14, 1935, of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

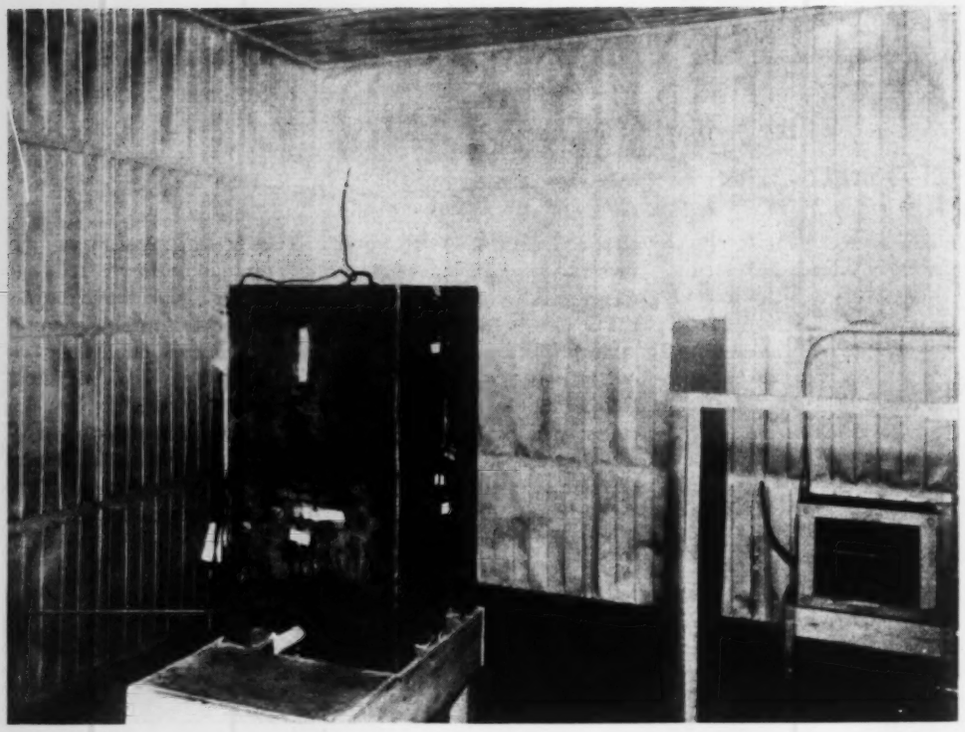

FIG. 3 INTERIOR VIEW OF HOT ROOM

The testing of thermal insulation involves the subjection of a sample wall to a low temperature on one side, to a higher temperature on the other side, the measurement of these temperatures, and the measurement of heat transferred. Of the several ways in which these measurements may be made, two have been used in testing steel insulation. The first, and perhaps the simpler, is known as the cold-box method. It consists of (1) placing a refrigerated box insulated with the material under investigation in a room maintained at a steady elevated temperature, (2) measuring the temperature of

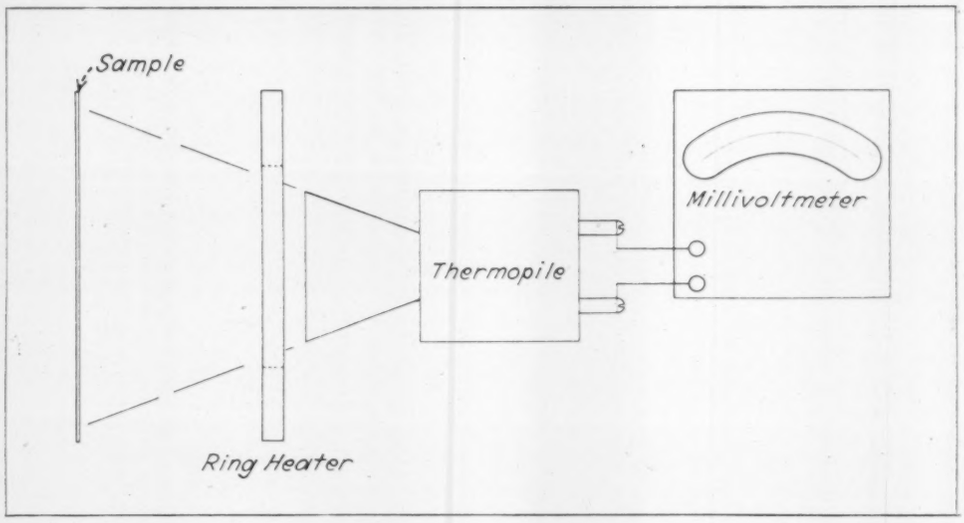

FIG. 2 THE INTEGRATING REFLECTOMETER

TABLE 2 INSULATION TESTS BY COLD-BOX METHOD

No. of sheets	Thickness, in.	Temperatures, F				Time to collect 25 cc melted ice, sec	Btu per hr corresponding to rate of ice melting	Btu per hr correction for drain temperature	Total heat transfer, Btu per hr	Box factor, Btu per hr per deg F	Coef, Btu per hr per deg F per in. of thickness per sq ft of mean area
		Outside	Inside	Difference	Drain						
4	2	101.4	49.9	51.5	39.2	212.0	134.4	6.7	141.0	2.74	0.235
4	2½	102.0	46.8	55.2	37.5	241.7	117.9	4.5	122.4	2.22	0.248
4	3	101.1	46.2	54.9	37.6	270.9	105.2	4.1	109.3	1.99	0.280
4	3½	100.9	45.6	55.3	39.2	272.6	104.8	5.2	110.0	1.99	0.342
3	1½	100.7	52.5	48.2	38.8	169.0	168.6	8.0	176.6	3.66	0.246
3	2	102.0	51.5	50.5	39.0	198.0	143.9	7.0	150.9	2.99	0.257
3	2½	100.6	49.0	51.6	39.3	226.2	126.0	6.4	132.4	2.57	0.288
3	3	101.3	47.8	53.5	38.6	238.4	119.5	5.5	125.0	2.34	0.329
2	1	101.7	59.0	42.7	39.4	132.7	214.8	11.0	225.8	5.29	0.209
2	1½	100.5	55.0	38.2	38.2	144.3	197.5	8.5	206.0	4.53	0.279
2	2	100.1	50.8	49.3	37.2	176.7	161.3	5.8	167.1	3.37	0.290
2	2½	100.2	51.0	49.2	39.6	198.4	143.6	7.6	151.2	3.07	0.344

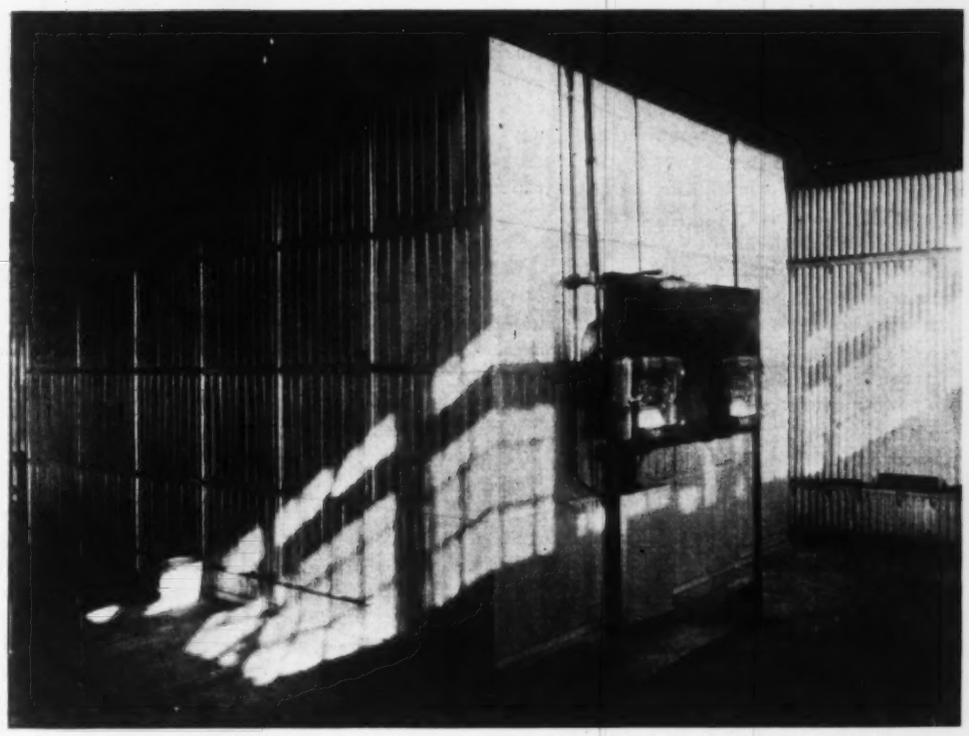

FIG. 4 EXTERIOR VIEW OF HOT ROOM

the inner and outer surfaces of the box, (3) measuring the rate of melting of ice or other suitable refrigerants, and (4) calculating from these data the coefficient of heat transfer through the insulated walls of the box.

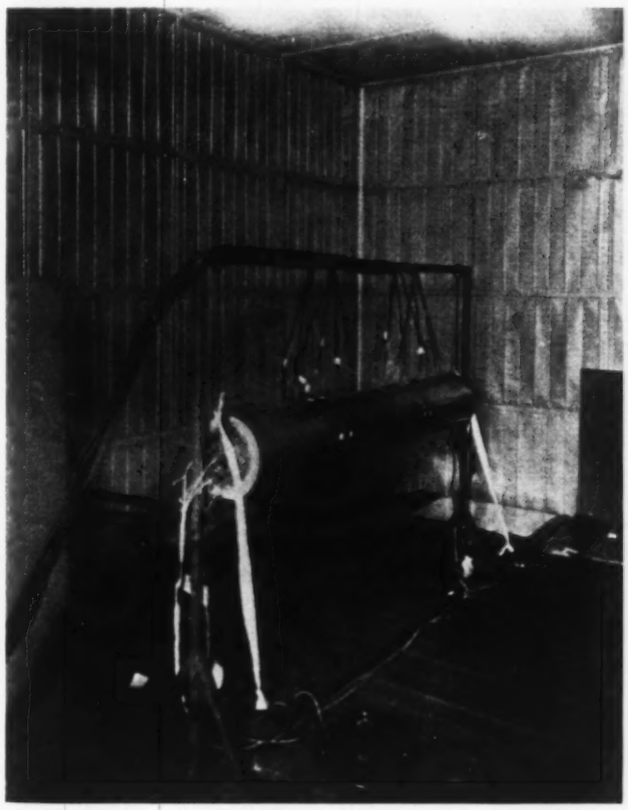

FIG. 5 ARRANGEMENT FOR TESTING SHEET-STEEL PIPE COVERING

A second method, especially adapted to measuring the insulation value of pipe covering, has been put into use. This consists of heating a length of insulated pipe with three separate sectional electric heaters provided with control rheostats so that temperatures at various points on the surface of the pipe may be equalized. When equilibrium has been attained, the electrical input to the center-section heater as well as the temperatures of the surfaces of the pipe and the surface of the insulation are measured. From these data, the heat conductivity of the pipe covering is determined.

Tests by the first method are conducted in a steam-heated hot room 12 by 17 by 9 ft high (Figs. 3 and 4) with walls 2 in. thick and insulated with three sheets of steel. This provides an insulation which permits reaching an equilibrium temperature rapidly. In this room, temperatures as high as 120 F may be reached and maintained automatically. Two fans, driven by constant-speed motors, maintain uniform circulation of the air. For test purposes a single refrigerator cabinet or a cold box of standard size is placed in the center of the room and cooled inside with ice. A measured block of ice of standard size is placed in the cabinet or box and, after equilibrium is attained, the rate of heat transfer through the walls of the box is measured by the melting rate of the ice. Inside and outside temperatures of the walls and the air temperature in the room are measured by fine-wire thermocouples attached to two eight-point potentiometer recorders located outside the room.

Comparative tests made with this equipment indicate that there is no practical difference in heat transfer through walls insulated with hot-rolled and annealed black plate which is the simplest available finish, and walls insulated with sheets of other grades of finish up to and including full-finished black plate. Because flat, scale-free sheets are needed in fabricating it is necessary to use full-finished sheets even though the cheaper finishes apparently are equally poor emitters of radiant energy at these temperatures.

For the cold-box method a standard box with an outer case 22 by 22 by 28 in. was used to make heat-transfer tests of insulating walls varying from 1 to 3 in. in thickness and containing

from two to four radiation shields. Data obtained in these tests and listed in Table 2 show the low conductivities attained. For example, two radiation shields in the 1-in. wall had a coefficient of only 0.209 Btu per hr per deg F per sq ft per in. It is interesting to note that steel insulation may be varied from about 0.195 upward by changes in the spacing and number of sheets used while other forms of insulation usually have a fixed insulation value.

A variety of methods for spacing the steel radiation shields and sealing off the air spaces between them have been developed. One method uses a board form of insulation to make frame-like separators both for spacing the sheets and sealing the air spaces. Another utilizes corrugated fiber-board frames and separators. Some all-steel panels have been made using 18–8 chromium-nickel-steel strips welded to the corners of the steel sheets for spacers. In these panels sealing was accomplished by paper strips held to the steel by asphalt, applied hot. In the hot room previously referred to wood separators are used quite successfully.

Testing has not been limited to the cold-box method, although at the present time there are available more data from this type of test than from any other. Sheet-steel pipe covering is being tested on an electrically heated test pipe 10 in. in diameter and 5 ft long illustrated in Fig. 5. The guarded-zone principle is used, making the actual test section 2 ft long. The heaters are segregated for a distance of 18 in. on either end and only the energy supplied to the 2-ft center section is measured. The input to the three sections is carefully balanced, temperatures are equalized over the surface of the pipe, and the electrical input to the center section is measured and used to calculate the conductivity of the pipe covering. Sections of 4-in. and 8-in. pipe are being similarly prepared. Data from tests on 10-in. pipe covering are listed in Table 3.

TABLE 3 TESTS ON COVERING FOR 10-IN. PIPE

Insulation	Pipe temperature, F	Temperatures at outer surface of insulation, F	Input to 2-ft length, watts	Coef, Btu per hr per deg F per sq ft per in.
4 sheet steel $^3/_8$-in. spaces	485	147	167	0.26
4 sheet steel $^3/_8$-in. spaces	475	161	172	0.26
85% magnesia $1^1/_2$ in. thick	597	146	238	0.28
85% magnesia $1^1/_2$ in. thick	537	142	206	0.27

Table 1 and Fig. 1 show that lead and zinc are good reflectors of the longer wave lengths, making it apparent that coated-steel sheets, such as terne plate, and galvanized sheets may be used for insulating purposes. They are available for those applications which require a corrosion-resistant surface.

In closing, attention is directed to Fig. 6, an artist's conception of a steel-insulated refrigerator cabinet for domestic use, showing two practical forms of construction. In the first form, shown in the bottom of the cabinet, the sheet-steel radiation shields are held in a properly spaced relationship by solid-form insulating material necessarily used in the corners of the box. In the second form of construction, the sheets of steel are held in place by thin stainless-steel strips, not shown, welded to their edge. The resulting air spaces thus formed are sealed at the edges by a strip of paper fastened to the steel by an adhesive material. About a thousand cabinets, similarly insulated have been constructed and are now undergoing service tests.

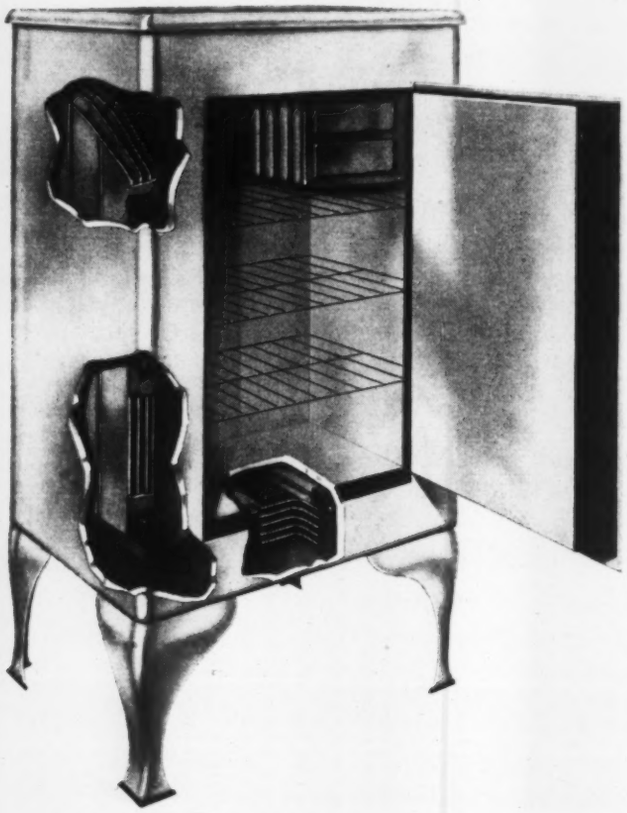

FIG. 6 STEEL-INSULATED REFRIGERATOR CABINET

The CREEP *of* STEELS

As Influenced by Macrostructure

By L. L. WYMAN

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

THE DEMANDS for higher efficiencies of equipment in certain engineering fields have necessitated the use of higher temperatures as, for instance, in boiler and turbine construction. Dimensional change of metals under stress at these elevated temperatures over long periods of time presents a problem that is becoming constantly of greater importance to the engineer and metallurgist.

The metallurgist is confronted with the problem of obtaining materials suitable for such service. When it is considered that the designers of such equipment demand materials which can resist a stress of 30,000 lb per sq in. without showing a total dimensional change, or creep, of more than the order of 1 mil per in., or 0.1 per cent, at the end of 100,000 hr, which is more than ten years, at 450 C (842 F), the selection and testing of materials assume gigantic proportions. The actual selection of materials can only be made justifiably as a result of long-time creep tests covering thousands of hours under stress at elevated temperatures.

Past experience has shown that resort must be made to alloy steels for such high-temperature service, and, as the future indicates still higher operating temperatures, it is evident that steels of high alloy content must be used. Not only must the material selected be of the proper chemical composition and receive the proper heat treatment but it must also be structurally uniform. This latter factor has been shown to be of vital importance as a result of creep tests conducted by engineers and metallurgists of the General Electric Company. In order to show the significance of structural uniformity on the creep properties of some steels, the results of several experiments will be described.

The first set of experiments concerns the metallographic examination of five steels which had been creep-tested with varying results. The five steels were of the Cr-Ni-Mo type, of approximately the same composition range, but came from different sources of manufacture. The compositions, heat-treatment data, and creep data on these five steels are shown in Table 1 in the order of decreasing creep strength.

These steel samples were tested for creep strength by the flow-rate test described by F. P. Coffin and T. H. Swisher.[1] In this test the sample at heat is first subjected to sufficient stress, say 40,000 lb per sq in., to produce an elongation of 0.1 per cent in two or three days. The loading is then stepped down successively to that load which will give a creep rate of 1 per cent per 100,000 hr, this stress being the nominal creep of the steel for that rate and total strain. The correspondence of such tests with constant-stress tests of several years' duration is understood, but it is beyond the scope of the present paper.

An analysis of the Table 1 clearly demonstrates that the chemical composition of the samples is not the determining factor in the great variations in their creep strength, for they are definitely of similar composition. Furthermore, the variations cannot result from heat-treatment because there are reversals in the results obtainable here, for with steel *B* there is practically no difference in creep strength between the heat-treated and annealed samples. On the other hand, the annealed sample of steel *C* is superior to the heat-treated specimen, whereas with steel *D* the heat-treated sample is the better. In an effort to gain definite information as to the cause of these inconsistencies, the steels were subjected to a microscopic examination with interesting results.

It was observed (1) that the extent of the variations in grain size in these samples was as inconsistent as the creep results, (2) that the degree of banding, or dendritic segregation, in these steels was in direct ratio to their creep properties in the annealed state, (3) that with material having no dendritic segregation, or banding, there existed practically no differences in creep strength due to the form of heat-treatment, whereas with a moderate degree of banding the heat-treatment may or may not increase the creep strength, and (4) that with severe banding, the heat-treatment usually is advantageous. The structural variations in the extremes in creep strength may be seen in Figs. 1 and 2, showing steels *A* and *E* as removed from test. These observations were immediately checked in several ways, including a recheck of past work in order to compare the degree of banding, or dendritic segregation, with the creep strengths. This recheck substantiated the observations mentioned in this paragraph.

Furthermore, direct experiments on severely banded material disclosed that materials with a creep strength as low as 12,500 lb per sq in. could be strengthened by heat-treatment to give results three times as high when tested at 450 C (842 F). It would seem, therefore, that these experiments have disclosed a cure and a specific for creep ills. The cure is the complete elimination of any banding or dendritic segregation, while the specific lies in being able to heat treat banded steel in order to give increased creep properties up to 450 C (482 F).

As a result of the examination of numerous test samples of the Cr-Ni-Mo steel under discussion, it has been demonstrated that the effect of heat-treatment persists throughout creep-test periods of several thousands of hours' duration at 450 C (842 F). In tests with samples run at temperatures in excess of 550 C (1022 F), it is known that a gradual annealing process takes place and that over a period of time the effect of any heat-treatment would be lost. If such a steel were used, for example, in a turbine, the loss of heat-treatment effect would ultimately result in a return to a structure of low creep strength. This may not occur until the turbine has been relegated to less important load schedules, and, therefore, the only noticeable effects would probably be a slight increase in steam consumption and a more definite need for annual refinement of balance.

Thus, in order to have a material of high creep strength, it is

[1] "Flow of Steels at Elevated Temperatures," by F. P. Coffin and T. H. Swisher, Transactions A.S.M.E., vol. 54, 1932, paper APM-54-6, p. 59.

Contributed by the Power Division for presentation at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

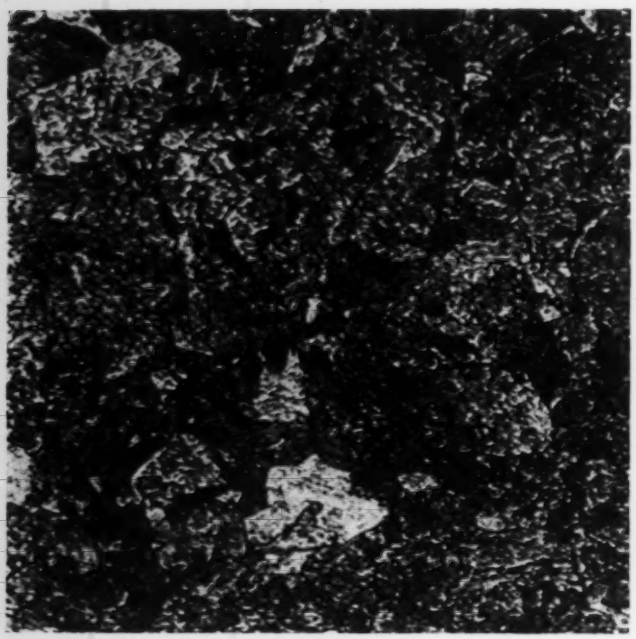

FIG. 1 SAMPLE STEEL *A* AS REMOVED FROM TEST
(500× — 2 per cent nital etch.)

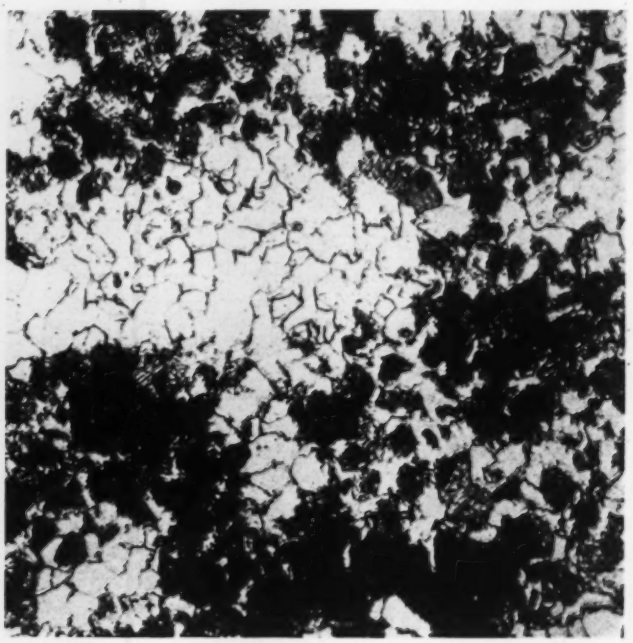

FIG. 2 SAMPLE STEEL *E* AS REMOVED FROM TEST
(500× — 2 per cent nital etch.)

obvious that it is essential to have a steel which is structurally uniform and free from banding or dendritic segregation. At present, however, it is unfortunate that the art of steelmaking does not seem to be able to furnish consistently material which is devoid of this evil.

In analyzing the effect of dendritic segregation on creep strength, it must be remembered that a chain is no stronger than its weakest link, and for the same reason a banded structure should not be expected to be any stronger than the low-strength ferrite bands it contains. The problem thus resolves itself into the ways and means for producing a structurally uniform steel.

Empirical experiments on banded steel have shown that a forging reduction of at least ten to one in diameter is necessary in order to produce a structure which is uniform and has an acceptable creep strength.

The effect of both heat treatment and forging is shown in an experiment wherein a piece of bolt stock 3-in. in diameter,

TABLE 1 CREEP-TEST DATA

Steel	C	Ni	Cr	Mo	Mn	Si	Heat treatment				Creep strength,[b] lb per sq in. 450 C (842 F)
A	0.35	1.91	0.85	0.46	0.56	Tr[a]	950 C (1742 F) A.C.	815 C (1497 F) A.C.	625 C (1157 F) A.C.	600 C (1112 F) F.C. at 30 deg per hr	36,000
B	0.33	1.77	0.77	0.30	0.55	0.18	...	950 C (1742 F) A.C.	600 C (1112 F) Mica cooled	...	33,000
C	0.31	2.05	0.83	0.45	0.54	0.11	825 C (1517 F) F.C.	675 C (1247 F) O.Q.	425 C (797 F) F.C.	...	30,000
D	0.34	2.74	0.61	0.25	0.60	..	835 C (1535 F) O.Q.	625 C (1157 F) O.Q.	400 C (752 F) F.C.	...	25,600
C	0.31	2.05	0.83	0.45	0.54	0.11	900 C (1652 F) A.C.	835 C (1535 F) O.Q.	625 C (1157 F) O.Q.	425 C (797 F) F.C.	18,000
D	0.35	2.74	0.61	0.25	0.60	..	825 C (1517 F) F.C.	625 C (1157 F) O.Q.	400 C (752 F) F.C.	...	13,000
E	0.37	1.78	0.77	0.36	0.55	0.16	...	825 C (1517 F) F.C.	...	...	11,500

A.C. = air cooled; F.C. = furnace cooled; W.Q. = water quenched; O.Q. = oil quenched.

[a] Trace.

[b] Initially strained approximately 0.1 per cent after which the stress is stepped down successively until a creep rate of 1 per cent per 100,000 hr is attained, such stress being the creep strength of the material.

badly banded, gave a creep strength of 12,500 lb per sq in. after being heat-treated for two hours at 950 C, followed by furnace cooling. A 10-in. billet of similar composition, cut from a 21-in. billet and reduced by forging to 1-in. bar stock, showed that all the banded structure had been kneaded out by the working. This bar with the same heat treatment as the bolt stock gave a creep strength of 29,700 lb per sq in. The effect of additional heat treatment, consisting of 950 C for eight hours, air-cooled, followed by 650 C for one hour and air-cooled again, is shown when the creep strengths of the bolt stock and bar stock were increased to 36,000 and 40,200 lb per sq in., respectively.

When it is considered that large forgings require ingots of extreme proportions if a twenty to one reduction is adhered to and keeping in mind that as ingot size increases so does dendritic segregation, the consideration of producing a structurally uniform section by forging reaches a stalemate.

Long-time soaking operations on the billet and bar have been tried in an endeavor to eliminate banding. The results to date, however, remain problematical.

An analysis of banding or dendritic segregation reverts directly to the ingot, to the manner in which the dendrites are originally formed. The formation of dendrites from the solidification of the metal in the mold is a problem in heat control, as has been proved many times during the many studies on the formations of solid grains in freezing liquids. The formation of crystallite solid from a freezing melt is a function of the rate of cooling. The solid grains grow from tiny nuclei, groups of atoms which under the proper conditions orient themselves to form the nucleus of the grain or crystallite into which they later grow.

Furthermore, the relationships between cooling rates and nuclei formation are not straight-line functions, but, to the contrary, under definite conditions there is a very pronounced maximum in the nuclei formation rate. When this is considered, together with the fact that the objectionable banded structure is caused by a condition of cooling wherein few large dendrites grow so large that a normal amount of forging could not eliminate them, it is obvious that the condition most advantageous to the attainment of a uniform structure is that in which as many nuclei as possible are formed simultaneously, resulting in, as nearly as is practicable, a minimum dendrite size. The cure, then, must consist of a controlled cooling of the molten metal in the ingot mold so as to give the maximum nuclei formation.

In an effort to verify this phase of the problem, at the suggestion of G. R. Brophy, a series of ingots has been made in the Research Laboratory where the mold temperature was varied from 100 to 550 C. The effect of this mold temperature can readily be observed in Figs. 3 and 4, showing a macrosection of the 4-in. ingots with 100 and 550 C mold temperature, respectively. Additional ingots have been made in which the steel was but partially killed, giving rise to an agitation of the freezing metal, due to gas ebullition, and thus resulting in a finer structure in the ingot.

These 4-in. ingots were forged into 2-in. bars, samples of which were taken for creep testing. The final creep results have yet to be obtained on these materials, but the results to date are very gratifying and show promise of being in excess of 35,000 lb per sq in. in creep strength for the unbanded material, the partially killed steel showing equally good results. These results to date are very definitely of superior creep quality and show that under properly controlled conditions a substantially dendrite-free or band-free material can be produced in the forged bar. This gives further proof that all creep testing must be considered from the standpoint of the structural uniformity of the steel. Although the chemical composition and heat-treatment both contribute greatly to the attainment of creep resistance, the influence of either or both may be minimized by a lack of structural uniformity.

Finally, it must be thoroughly realized that the value of any particular alloying elements or combination of elements, as well as the value of heat-treatment can only be determined when applied to structurally uniform materials.

In conclusion, the author wishes to express his appreciation to his associates in the General Electric Company who have so materially assisted in the preparation of this paper.

FIG. 3 4-IN. CAST IN MOLD HEATED TO 100 C
($2^1/_2\times$ — Amm. persulphate etch.)

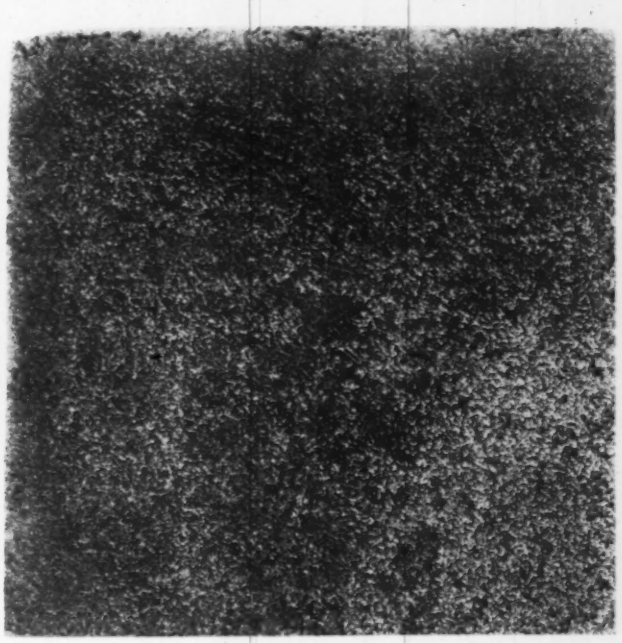

FIG. 4 4-IN. INGOT CAST IN MOLD HEATED TO 550 C
($2^1/_2\times$ — Amm. persulphate etch.)

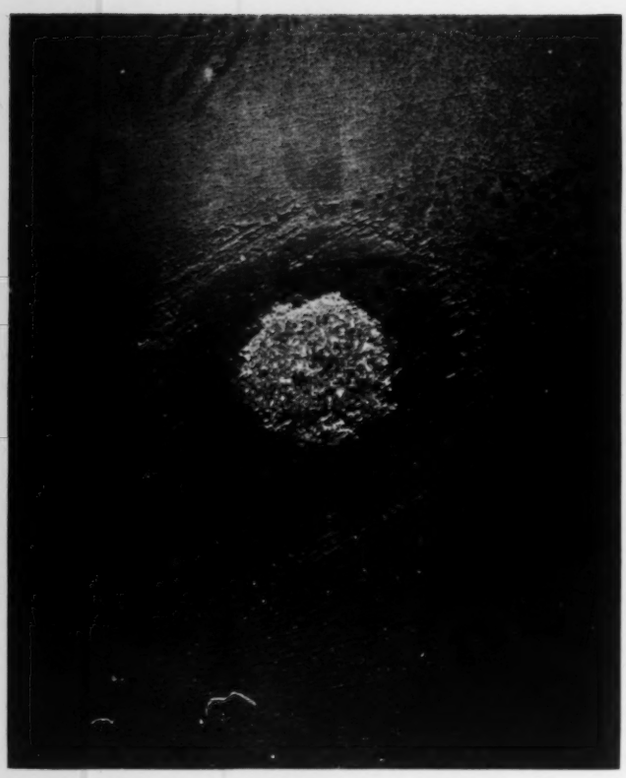

FIG. 1 THE APPEARANCE OF NORMAL IMPINGEMENT ATTACK

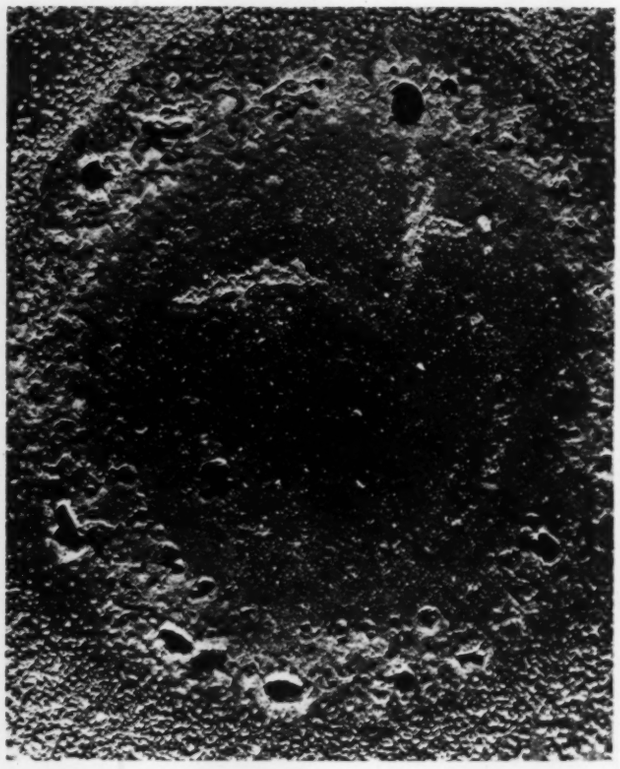

FIG. 2 PENETRATION EFFECT OF PIN-HOLE IMPINGEMENT ATTACK

Recent Development in CONDENSER TUBES

As A result of the investigation of test methods now in use for determining the comparative resistance of condenser-tube alloys, the Subcommittee on Standards of the A.S.M.E. Special Research Committee on Condenser Tubes has reported that testing by impingement attack and by the use of experimental condensers operating under controlled conditions produce results of considerable value in predicting the relative service characteristics of the alloys. It is pointed out, however, that the ultimate comparison must be determined by actual service, even though actual service does not permit suitable control for standardization of conditions.

CORROSION TEST USING EXPERIMENTAL CONDENSERS

The Naval Engineering Experiment Station at Annapolis, Md., has been conducting a series of experimental condenser tests for more than six years in which a number of condenser-tube alloys are being compared. The test equipment consists of eight small single-pass condensers grouped radially about vertical distribution headers for steam, cooling water, and condensate. Each condenser has 6.35 sq ft of surface area and contains 16 tubes, $^5/_8$ in. in diameter, $31^1/_8$ in. long, and spaced $1^1/_{16}$ in. on centers, which are rolled into the tube sheets on the inlet ends and packed with metallic packing on the outlet ends. The tube sheets, which are one inch thick, are spaced 31 in. between outside faces and are joined by a shell of 6-in. steel pipe with cast-iron flanges at each end.

During the tests a steam rate of 63.5 lb per hr was used, this being equivalent to 10 lb per sq ft of condenser surface. When the test was first started, the average cooling-water velocity was approximately 6 fps, this velocity demanding a water rate of 3200 lb per hr, or 50 lb of water per lb of steam condensed. The cooling water was aerated by injecting air against the flow of water, the weight of the air being approximately 0.2 per cent that of the water. Severn river water having an average salinity of one-third that of sea water was used during the tests.

About two years ago the average water velocity was increased to 8 fps. At this velocity 3750 lb per hr passed through each condenser, or approximately sixty times the quantity of steam condensed. In addition, the weight of air injected into the

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Abstract of Progress Report No. 8 contributed by the A.S.M.E. Special Research Committee on Condenser Tubes and presented at the Annual Meeting, December 3 to 7, 1934, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The personnel of the committee is as follows: Albert E. White, chairman; Bert Houghton, vice-chairman; Paul A. Bancel; R. H. Barber; Donald K. Crampton; Harvey M. Cushing; Harold F. Eddy; Vincent M. Frost; Walter L. Green, Jr.; Charles F. Harwood; C. F. Hirshfeld; Howard W. Leitch; Ernest F. Miller; William B. Price; Horace A. Staples; William R. Webster; Robert Worthington.

water was increased to 0.7 per cent of the weight of the water.

The condensers are operated only during the working hours, being shut down the remainder of the day and on Sundays and holidays. The water boxes on the condensers are removed once a year and the tubes cleaned and inspected. The shell of each condenser with tubes and sheets in place is tested with air under a pressure of 15 lb per sq in. Any leakage through the wall of the tubes is detected by the use of a soap solution brushed over the tube ends. A small periscope with a miniature electric-bulb attachment is used for close inspection of the interior surface of the tubes.

Various condenser-tube materials have been tested or are now being tested in these condensers. One Admiralty-metal tube failed after 1250 hr of actual operation. However, the remaining fifteen Admiralty-metal tubes are still in service after a total of 11,300 hr. Monel metal has given satisfactory service up to the present time, no failures having occurred since the start of the test, a total of 11,300 hr.

One type of 18–8 stainless-steel tube failed after 625 hr of operation, as did two different grades of tubes, containing approximately 17 per cent chromium without the addition of nickel, after 950 and 1060 hr of service. Other alloys of the 18–8 type, however, are still in operation after 4000 to 5000 hr.

Two grades of aluminum-bearing copper-zinc tubes failed after a comparatively short time although two other grades have been in operation for approximately 2525 and 3850 hr and still appear to be in good condition. The copper-nickel alloy tubes of various compositions appear to be in good condition after approximately 9300 to 10,300 hr of service. There are a number of tubes of other compositions in the condensers at the present time, but because of the short interval since their installation, no decided deterioration or failures have occurred up to the time this report was compiled.

The nature of the failures which have occurred has been of two general types, namely, dezincification and pitting. Dezincification of the plug-type occurred in the Admiralty-metal tubes and in the two grades of aluminum-bearing copper-zinc tubes. The 18–8 and 17 per cent chromium tubes failed as a result of pitting which was fairly general throughout the tubes.

CORROSION TESTING BY IMPINGEMENT ATTACK

In the review[1] of corrosion-test methods submitted by the subcommittee on standards at the meeting in 1933, the conclusion was presented that studies of corrosion by impingement attack give a better indication of the manner in which alloys will resist corrosion in condenser-tube service because of the definite effect of velocity on corrosion rate. The studies reported to this committee two years ago by J. R. Freeman, Jr., and A. W. Tracy on the effect of impinging velocity on corrosion rate have been continued, but the equipment used has been modified so that the impinging stream travels vertically upward, carrying the air with it. It has also been found more desirable to draw the air into the solution by a suitable venturi on the discharge side of the pump rather than at the intake.

A modified type of impingement-testing apparatus developed for this type of corrosion testing consists of a series of monel-metal nozzles and specimen-holding clips mounted vertically on an air pipe immersed in a trough of constantly flowing water. Air pressure of 4 to 16 oz per sq in. causes a stream of air bubbles to issue from the jets and impinge on the lower surfaces of the sample. As a result of tests made on Admiralty-metal specimens for the purpose of determining the optimum distance between the sample and the jet, $^5/_{16}$ in. was chosen as standard on the basis of depth of attack and uniformity of results.

[1] See MECHANICAL ENGINEERING, July, 1934, pp. 439–440

Two distinct types of pitting were encountered in the tests made with this apparatus. In the normal type, the sample developed a smooth circular-shaped bright spot of attack at the point of impingement. The other type of attack was of a pin-hole appearance and it penetrated more rapidly than the normal type. In mild cases, it took the form of clearly defined isolated circular pits, the inside surfaces of which were covered with dark-colored scale. Where the attack was more severe, these pits tended to be arranged in concentric circles about the point of impingement. Typical examples of the two types of attack are shown in Figs. 1 and 2. Variation in surface condition of the sample, the amount of air used, and the distance from jet to sample apparently had no effect upon the type of corrosion produced.

In three tests which were run for the purpose of comparing Admiralty 5 per cent aluminum bronze and aluminum brass *A*, all samples were attacked to some extent with Admiralty metal being more deeply attacked in all three tests. None of the samples, however, showed pin-hole attack, and in only one test did the 5 per cent aluminum bronze show any attack whatever.

A test comparing Admiralty 5 per cent aluminum bronze, aluminum brass *A*, and 70–30 cupro-nickel was made with water temperature at 73 F. All samples developed pin-hole attack, although this was the only test in which Admiralty 5 per cent aluminum bronze and 70–30 cupro-nickel showed this type of attack, all other tests showing normal impingement.

There followed a series of ten tests in water varying between 31 F and 58 F in which Admiralty metal was compared with one or more other alloys. The depth of attack on Admiralty metal in those runs where Admiralty metal and 70–30 cupro-nickel were compared was from 3.2 to 3.5 times as great as the attack on 70–30 cupro-nickel. All samples of aluminum brass *A* and *B* suffered pin-hole attack to a marked degree. In four tests, the 5 per cent Admiralty aluminum bronze showed no attack, while in two tests there was a slight tendency toward pin-hole attack. Two tests comparing fine-grained and coarse-grained Admiralty metal indicated that there was little difference in the rate of attack.

In addition to these results of corrosion tests by impingement attack and by the use of experimental condensers, a suggestive analysis of tube failure due to pitting has been made by the research laboratory of a tube manufacturer. The laboratory report stated that there is not the slightest doubt that in every case the failure of the tubes tested was due to some foreign body having become lodged in the bore of the tube at or near to the point at which it was punctured. The illustrations in Fig. 3 reveal the nature of the pitting and its proximity to the lodged body. The evidence submitted in this case is of particular importance as it gives concrete support to a theory which has been expressed from time to time, explaining the cause of certain failures concerning which there has been a wide divergence of opinion. Furthermore, it stresses the importance of a smooth tube surface, free from flaws and imperfections on which foreign matter might tend to lodge.

PERFORMANCE OF NEWER ALLOYS

The status of the newer condenser-tube alloys has not changed during the past year. Some reports have been received, however, on the durability of these tubes but it is pointed out that the data in such cases are not always representative of average operating conditions. Frequently the new alloys are tried only after conventional tube material has failed to give satisfaction because of the severity of service conditions.

Tubes of aluminum bronze (95 per cent copper and 5 per cent aluminum) are reported by a central station on the Atlantic seaboard as having given 86,000 hr of service. It is further

reported that only recently have the tubes begun to fail at a slightly accelerated rate.

Aluminum brass has given varied results in central-station installations. Four users report satisfactory service while an equal number report failure from local action or general thinning at the inlet end in from nine to fifteen months. In marine service, one user reports the life of aluminum brass in New York harbor to be about two-thirds that of Admiralty metal. Three steamship operators in coastwise service are reported to have obtained satisfactory service from aluminum brass while four others find that it has little advantage over Admiralty metals.

Copper-nickel tubes have been reported as giving satisfactory service in five marine installations covering a period of about three years, while an analysis of three other marine installations revealed that the copper-nickel tubes failed within less than a year. No report has been received regarding the performance of these tubes in central-station installations.

One central station on the Atlantic seaboard is conducting an extensive experiment to obtain data on relative tube life under actual operating conditions. Groups of alloy tubes up to 500 in number have been placed in various parts of the condensers. Up to the present time the tubes have given 15,000 hr of service, but tube failures have been so few and scattered that no conclusion can be drawn. The following tube materials are being tried by this method: (1) 95 per cent copper, 5 per cent aluminum, (2) 76–77 per cent copper, 21–22 per cent zinc, 2–2½ per cent aluminum, (3) 94 per cent copper, 3 per cent zinc, 3 per cent aluminum, and (4) 80 per cent copper, 17 per cent zinc, 2 per cent aluminum, 1 per cent nickel.

The status of the use of newer alloys has not changed materially in the past year. Due to many examples of excellent service, these alloys have established a strong position in the condenser-tube field. The cases of complete failure merely emphasize the fact that local service conditions in these cases require further analysis. No approach can be made to a hard and fast rule for the best application of any of the better-known tube mixtures until performance data under various operating conditions have been obtained and have been completely analyzed.

Reports have been received that the protection of the inlet end of tubes by painting is meeting with continued success, one steamship operator stating that the life of Admiralty-metal tubes has been increased from two years to approximately four years by this form of protection.

Cases of tube corrosion resulting from the presence of strong corrosive agents in the circulating water or in the condensate also have been reported. In one case, ammonia was found to be present in the condensate while in the other sulphite or bisulphite solutions were emptied by a nearby manufacturer into the stream supplying the cooling water.

A case was reported of severe end corrosion of the tubes in a condenser on the Atlantic seaboard in which the use of special inserts apparently has successfully overcome the conditions. Tubes of a highly resistant alloy of copper, aluminum, nickel, and zinc were first used to overcome the trouble but they showed evidence of failure in even a shorter time than the Admiralty-metal tubes which they replaced. Since the cooling water was not contaminated, it was thought that the high suction lift on the circulating pump caused a large proportion of the dissolved and entrained gases to be liberated from the water, resulting in severe impingement attack at the inlet ends of the tubes. For the protection of the inlet ends of the tubes, special inserts of copper-nickel-tin alloy were cemented into the tubes. These inserts were designed without large diameter bells and were made to fit closely on the tube ends, thus eliminating protrusion into the water box with its consequent turbulence and the possibility of dislodging the inserts. The inserts were internally reamed on the downstream end to avoid cavitation at that point. Subsequent examination of the tubes in this condenser showed that end corrosion has been greatly retarded.

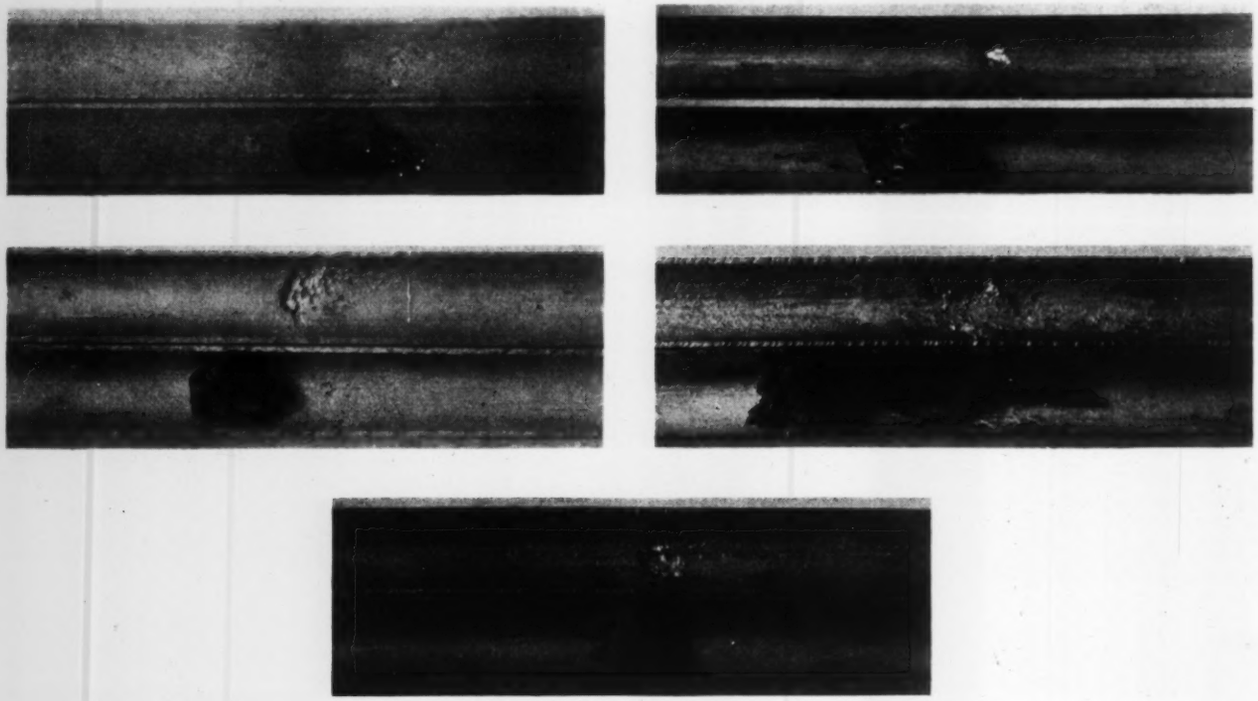

FIG. 3 PITTING CAUSED BY FOREIGN SUBSTANCES LODGED IN CONDENSER TUBES

STREAM POLLUTION *and* TEXTILE WASTES

By C. D. BLACKWELDER

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THE PROBLEM of stream pollution due to textile wastes is becoming increasingly important to the textile industry. This is evidenced by the fact that almost every state in the Union now prohibits the discharge of objectionable waste materials from industrial plants into streams.

Waste materials high in oxygen-consuming power cause the stream to give up its dissolved oxygen in order to supply oxygen for the oxidation of the wastes, after which there may or may not be any dissolved oxygen left in the water. In any stream the existing condition regarding dissolved oxygen is the resultant of the two opposing forces of deaeration and reaeration, the former of which is due to pollution of the water. Shallow, swiftly running streams reabsorb oxygen at a high rate from the atmosphere, while on the other hand, deep, slowly moving streams have little chance of reabsorbing oxygen.

The degree of treatment required for textile wastes varies greatly with local conditions. Because every case of stream pollution has different characteristics and because the degree of purification required is not the same for all plants, the problem is often complex and cannot be solved without engineering advice. This is especially true when it is realized that the required treatment of the wastes must be an economical one, inasmuch as it involves an overhead expenditure, and therefore may result in converting plant operation from a profit to a loss if there is great competition in the manufacturing field in question.

The present statutes in force in many states concerning the discharge of textile wastes into streams are of importance to organizations seeking locations for new plants because they concern not only the disposition of wastes but also a supply of water suitable for textile processing. In nearly every case the law includes a penalty for violation of the statutes although legal action is taken only when there appears to be no disposition on the part of the manufacturer to effect a remedy. General practice follows a policy of cooperation with the industries rather than the enforcement of severe requirements. Federal control over discharge of sewage and industrial wastes into streams, lakes, and coastal waters, is being sought because it is felt in many circles that since tributaries of navigable streams constitute a part of such waters they should be subject to the jurisdiction of the federal government.

The water from many streams is not used for drinking and industrial purposes, and to demand that a manufacturer located on such a stream purify his waste discharge to a crystal-clear drinking-water standard would be placing an unjustifiable burden upon him. Some states are recognizing this fact, and only require that the wastes be treated to such a degree that they will not be objectionable to land owners along the stream, and will not kill fish. Many industrial plants discharge relatively clear wastes, without chemical pollution. The color of a waste may or may not be an index of the polluting power of the waste. In many cases, a small amount of dye waste imparts a distinct color to water, yet does not impair its chemical quality. There are other cases where a nearly colorless waste may, because of its high oxygen-consuming power, acidity, or alkalinity, be very harmful.

Textile industries which discharge large volumes of liquid wastes containing high percentages of organic solids, highly colored spent dye and kier liquors, acids, starch wastes, and other chemical compounds are the main offenders. Of all the wastes here mentioned, the kier liquor, containing free caustic organic matter and having high oxygen-consuming power, is the most difficult to dispose of properly.

What to do in order to eliminate or reduce stream pollution is a problem requiring intensive study, and it is not within the scope of this paper to undertake to describe the various means of treatment. The solution of textile-waste problems involves much more than simple chemistry. It involves also the knowledge of general engineering principles. The problem can best be solved by the chemical engineer, thoroughly familiar with textile bleaching, mercerizing, dyeing, printing, and finishing operations, and the chemicals used in these various processes. He should have well-equipped experimental and research laboratories to work out the various chemical reactions vital in the treatment and disposal of wastes economically.

Treatment of textile wastes is one of the problems that the textile manufacturer usually defers until pressure from an outside source is brought to bear. Many textile plants that are now threatened with lawsuits from property owners along the streams which are polluted with textile wastes could put in the necessary plant for treating their wastes for far less than the cost of damage suits or injunctions, and at the same time avoid acquiring the ill will of the public. These wastes are complex in composition and therefore cannot be treated properly without expense.

As waste treatment costs money, it is neither economical nor efficient engineering to design a waste-disposal plant to turn out a clear neutral effluent, if that degree of purification is not necessary. Various methods of treatment and disposal of textile wastes have been devised, but in this short paper no attempt will be made to describe these various methods, one exception being a general type of treatment plant which makes use of chemical precipitation.

TREATMENT BY CHEMICAL PRECIPITATION

The wastes discharged from a textile bleaching and finishing plant are acidic, neutral, or alkaline. Inasmuch as these conditions may vary from hour to hour it is necessary to make a careful study of the natural reactions between these various wastes. Provision should also be made for possible changes in the manufactured product that will of necessity change the chemical processing in the plant, which in turn changes the nature of the waste produced.

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In some cases it is found best to collect all the wastes discharged from a plant into an "averaging" basin or tank before any chemical treatment is applied. In other cases two or more types of wastes should be collected into a basin, while one or more other kinds of wastes should be collected in another basin. After the natural reactions take place between the various wastes in a certain basin they are brought together in a control chamber to produce, as nearly as possible, a standard solution of wastes. In such a chamber the flow of wastes to be treated is controlled automatically with such accuracy that the application of the chemical treatment will remain correct throughout the day. The wastes should flow from the control chamber into a mixing chamber where they will be thoroughly mixed with the applied chemicals. After applying the chemical treatment to the wastes, they flow into a flocculation or contact chamber, then into a settling basin. Most textile wastes, when chemically treated, produce a feathery floc, which is much more delicate than the floc produced in the treatment of water before filtering. This makes it necessary to avoid any hydraulic disturbances that would cause this floc to break up and redissolve. Large volumes of sludge are produced and means must be provided for removing this sludge at regular intervals or continuously, the latter way being the best since it makes possible the use of smaller settling basins. Two plants processing exactly the same kind of textiles may have wastes that are different in character; therefore, the wastes would require entirely different chemical treatment.

It is necessary to design the settling basins for the required retention period and flow-through velocities in order to allow complete precipitation of solids that will settle out. The proper design of the settling basin is a much greater problem than the design of similar basins for water treatment.

In most cases, if the waste problem has been properly solved, the chemical reactions worked out correctly, and the hydraulics of the plant's design is good, no further treatment of the waste will be required. In certain cases, the settled clarified effluent will require filtering, secondary sedimentation, or further chemical treatment for neutralization or stabilization. In order to handle the drying of the precipitated sludge in the settling basin, sludge-drying beds, or lagoons must be provided. In many cases a portion of the precipitated sludge can be returned continuously to the mixing chamber to aid in the treatment of waste material, thus reducing the cost of chemical dosage.

Many manufacturers have a mistaken conception of the cost of a plant for the disposal of textile wastes. When local conditions are suitable, the "averaging" basin can be constructed of earth. Concrete is used only where agitation occurs and for the settling basin. These plants can be designed to be almost automatic in operation, requiring an attendant for a few minutes only each day. Where space is limited, the disposal plant can be designed on the upward-flow principle, the tanks being made of concrete or steel.

This type of plant would produce all the functions and reactions that normally take place in a plant laid out for horizontal flow, and can be used advantageously by industries located in municipalities where ordinances require pretreatment of textile wastes before discharging them into sanitary sewerage systems. With this type of plant, wastes can be treated so that they will neither cause disintegration of concrete surfaces of manholes, sewer pipes, and sewage-treatment structures, nor hinder the proper operation of the sewage-disposal plant.

In designing plants for waste disposal, a careful study should be made of the correct chemicals to be used in the treatment process. Patented compounds should be avoided because they are usually higher priced than simple chemicals which can be obtained in the open market. In some cases a larger initial investment in the plant is warranted when a reduction in the daily use and cost of chemicals can be made as compared with a less expensive plant requiring a much more expensive chemical dosage.

The cost of plants for disposing of textile wastes and the cost of the chemicals for operating them vary greatly with the capacity of the plant, the character of the wastes, the dilution factor of the receiving stream, and other local conditions. The initial cost of the plants varies from $35 to $400 per 1000-gal capacity per 24 hours. The chemical cost for operation varies from a quarter of a cent to seventy-five cents per thousand gallons of waste treated.

Manufacturers should keep in mind the possible necessity of having to treat industrial wastes where danger of lawsuits or injunctions are imminent. A detailed study of conditions may reveal a waste of chemicals in the processing of the textiles that could be eliminated at quite a saving and at the same time partially eliminate some of the causes of stream pollution.

MACHINES THAT WELD TWO 72-IN. SEAMS OF FORD V-8 BODY IN SEVEN SECONDS. EACH MACHINE IS 14 FT. HIGH, WEIGHS 28 TONS, AND EXERTS PRESSURE OF 2000 LB TO LINEAR INCH OF WELD

An OIL MANOMETER

Description of a New Instrument for Measuriug the Absolute Pressure of Steam in Condensers

By G. H. Van HENGEL and J. D. STARKWEATHER

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IN TESTING the condensers of steam turbines it is desirable to measure the back pressure with an instrument which can detect changes of a few thousandths of an inch of mercury. This is necessary not only for the measurement of small pressure differences, in which errors of the order of a hundredth of an inch of mercury are inadmissible, but also to enable the true temperature of the saturated steam to be evaluated from the pressure observation with a reasonable degree of accuracy. This evaluation is necessary to express temperature differences such as occur between the saturated steam at some point in the condenser and the inlet cooling water. To observe this desired temperature difference within 0.1 F at a steam temperature of 50 F, as in winter, a pressure measurement accurate to 0.001 in. of mercury is required, and at a steam temperature of 100 F, as in summer, a pressure measurement accurate to 0.006 in. of mercury is necessary (1).[1]

The authors have used barometric-type vacuum gages in combination with the power-plant barometer for their earlier measurements of condenser pressures. Because of the well-known difficulties experienced in keeping the meniscus clean (2*a*, 5*d*) the desired accuracy is subject to serious impairment through unknown variations of the meniscus correction. In addition to the necessity for frequent applications of a specialized and cumbersome cleaning process, which often has to be done at inconvenient times, the technique of reading the gages is elaborate and requires a well-practiced observer. It is felt, therefore, that a new kind of instrument is desirable which will not only be more accurate but more practical from the standpoint of power-plant testing.

Features of the Absolute-Pressure Oil Manometer

For the past two years the authors have been using four oil manometers of a type which is new in power-plant testing practice although well known in certain fields of research. Experience has shown that this type of gage yields accurate results, is easily read, and requires little attention to be kept in satisfactory condition.

It is similar in principle to a gage developed by K. C. D. Hickman (2, 5*e*, 6*a*, 7), to whom the authors are indebted for a great deal of assistance in applying the method to their problem. Essentially a U-tube manometer, it differs from the conventional absolute-pressure manometer in that it contains a non-volatile organic liquid in place of mercury and in having the high vacuum in the reference leg maintained by a condensation pump[2] (8*c*) connected in series with a high-vacuum mechanical pump.

It is the low specific gravity of the oil filling which affords the high sensitivity of this gage, for the deflection is about thirteen times that resulting from the use of mercury; a further advantage of the large deflection is that capillary errors, of much moment when mercury is used, become a negligible percentage of the total deflection. The oil filling, however, must satisfy these requirements: It must have a very low vapor pressure, as this is necessarily the reference pressure of the gage; it must not absorb water, since the gage is exposed to water vapor; and its properties, especially its density, must be stable so that frequent calibration of the gage need not be required.

Di-n-butyl phthalate, which fulfills these requirements, is the liquid which has been used by the authors. It has nearly the same density as water, yet its vapor pressure at 32 F is approximately one one-hundredth that of mercury, and as it is an oil, water will not go into solution with it. It does, however, absorb air and other gases (5*f*) and it is because of this unfavorable property that the reference leg of the gage cannot be sealed but must be connected to a high-vacuum pumping system. Additional data on di-n-butyl phthalate are given in the appendix.

For power-plant testing, the use of a high-vacuum pumping system might well be impracticable but for the development of the miniature condensation pump filled with a non-volatile organic liquid (3, 5). This has two practical advantages: The use of an air-cooled condenser instead of a water-cooled condenser as required for a mercury condensation pump; and a low electrical input for its operation, which, with the authors' gages, is about 35 watts for each pump. At the present time, the most suitable non-volatile oil for use in a condensation pump is di-n-butyl phthalate; so that this same liquid, the use of which in the manometer requires a high-vacuum pumping system, makes the use of such a pumping system suitable for a portable gage.

Description of the Absolute-Pressure Oil Manometer

Fig. 1 shows the latest design of this gage, which will measure pressures up to three inches of mercury absolute. The gage is protected against exposure to pressures greater than the maximum by means of the splash bulbs at the top of the manometer legs and by means of the ground-glass by-pass cock.

An electrically heated, miniature glass condensation pump operated with di-n-butyl phthalate and its air-cooled condenser are built integral with the gage, and when in operation are connected in series to a rotary oil pump (6*d*, 8*b*) discharging into the atmosphere. Incorporation of the condensation pump with the gage itself reduces to a minimum the length of line under highest vacuum, which insures the lowest possible pressure in the reference leg of the manometer. The pump size is directly related to the diameter of the manometer leg, as it is of no use to make the pump-jet diameter any greater than that of the tubing on its suction (6*c*).

[1] Numbers and letters in parentheses refer to the bibliography at the end of the paper.

[2] In theory, a condensation pump can completely evacuate a given space of all molecules; in this case the lower limit of pressure attainable is the vapor pressure of the liquid in the top of the closed leg of the manometer.

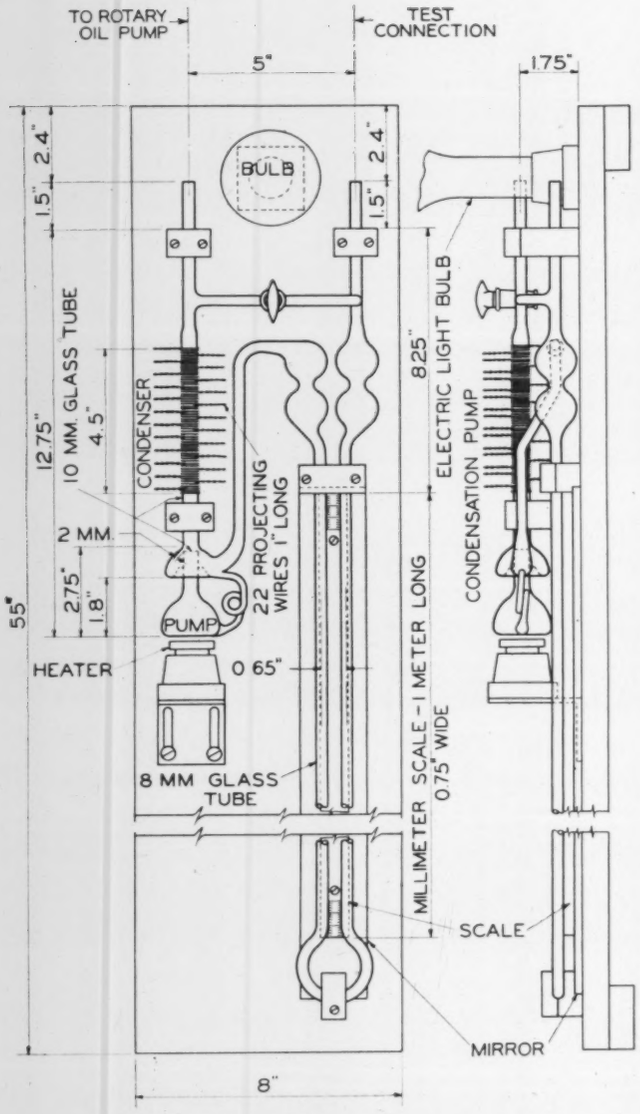

FIG. 1 ABSOLUTE-PRESSURE MANOMETER

The electric heater for the condensation pump is connected in series with an electric-light bulb mounted on the gage board. Adequate regulation of the input to the heater is afforded by the use of bulbs of various sizes, and an important feature of this arrangement is that when a heater burns out the extinguishing of the light attracts immediate attention. The authors' experience was that the heaters lasted through many days of operation; each heater was a 110-volt, 80-watt, non-automatic cigar lighter connected in series with a 110-volt, 150-watt bulb. Proper operation of the di-n-butyl phthalate condensation pump is evident to the eye. The liquid boils without "bumping" and a film of condensate from the condenser is to be seen running down the pump side wall.

Errors in reading caused by parallax are avoided by mounting the scale of the gage on a mirror. The horizontal distance between the outside of the U-tube legs is slightly greater than the width of the scale, so that in reading the gage the reflection of the eyeball may be lined up with the meniscus. The scales used by the authors are of wood and their correction for thermal expansion can be neglected.

INSTALLATION OF AN ABSOLUTE-PRESSURE OIL MANOMETER

The di-n-butyl phthalate condensation pump is quite sensitive to the pressure against which it operates, which must in any case be less than 0.040 in. mercury absolute, both for satisfactory pumping action and for preventing decomposition of the liquid from continual boiling under too high pressure (*3d*). In the authors' practice, the condensation pumps of all the gages used are served by the same two-stage rotary oil pump, which is rated at 0.0001 mm (0.000004 in.) Hg for the degree of vacuum attainable.

The greatest attention must be paid to the set-up of the high-vacuum lines on the rotary-oil-pump suction. Except during the starting period of the gages, the flow in these lines is likely to consist not so much of discharge from the condensation pump as of leakage at joints and liberation of gas from the walls of the connecting rubber tubing. In accordance with laboratory high-vacuum technique (*5a*, *8d*) rubber-tubing connections must be as short as possible and of a quality of rubber designed for high-vacuum usage. The joints must be sealed with a grease of low vapor pressure and wired tight. Greases with a castor-oil or apiezon-oil base are recommended. After completing the assembly of a set-up it must be prepared for use by evacuating it with the mechanical pump for a period of about twenty-four hours, which removes gases from the liquid in the gages, the wall surfaces of the lines, and from the lubricating oil of the rotary oil pump. This treatment need not be repeated for this length of time, however, even if the assembly has been out of use for several weeks. After this first treatment and an unchanged assembly of apparatus, the time required to get a gage into proper operation is only the few minutes necessary to heat the liquid in the condensation pump to the boiling temperature. It is because of the necessity for a preliminary degassing of the apparatus that the authors use a high-capacity, rotary oil pump; although a pump of very low capacity is adequate to keep the gages in operation (*8a*).

The set-up shown in Fig. 2 is satisfactory; the gages shown at the left are of an earlier design than that shown in Fig. 1. There are five rubber-tubing connections in the high-vacuum section of the set-up, which are of quality recommended by the manufacturer of the rotary oil pump for use on its suction lines: one piece of tubing $^1/_4$ in. inside diameter at each condensation pump discharge and one piece of tubing $^5/_8$ in. inside diameter at the rotary-oil-pump suction. The joints of these pieces of rubber tubing are sealed with a castor-oil-base grease and wired tight. The rotary oil pump is rated at a capacity of 30.6 liters of free air per minute and is not provided with a refrigerant trap (*6b*, *8e*). Connection between this pump and the gages is made with a copper-tubing manifold made of four $^3/_8 \times 12$-in. tubes connected by soldered tees to a $^3/_4 \times 120$-in. tube.

OPERATION OF THE ABSOLUTE-PRESSURE OIL MANOMETER

In use, the degree of vacuum in the closed leg of the manometer has been checked by observing the character of an electrical discharge produced within it by means of an electric vibrator (*8e*). If the vacuum is poor, the discharge in the glass tubing appears as a stringy line with a pronounced violet color; with a good vacuum, the discharge is a uniform glow which is pale green; and the better the vacuum, the less the evidence of color. The first gages were made in March, 1933, and were checked against a McLeod gage (*9*) with a liquid-air trap in a laboratory set-up and proved to be accurate to within 0.002 or 0.003 in. of mercury. In reference to sources of error see the paper (*2a*) by Hickman. When the gages are set up on a test, in addition to the check with the electric vibrator the authors make a check at pressure connections where it is known that there is air-free saturated steam by measuring the temperature

and comparing that observation with the saturated-steam temperature corresponding to the pressures observed by the gage. The two temperatures should agree within 0.3 F when the fluctuations of steam flow have been eliminated as far as possible by control of conditions on the turbogenerator unit.

Special care is necessary in starting up to avoid accidental exposure of the gages to pressures in excess of their range (10). In the authors' practice, every line between each gage and the pressure connection of the condenser of the turbine is provided with two clamps, one on the piece of rubber tubing between the copper line and the gage, and the other on the piece of rubber tubing between the line and the nipple of the condenser pressure connection. Valves are not put in these lines because of the attendant excessive leakage through their stem packings. The latter clamp is intended for protection of the condenser in case of any accident to the line or gage system which would admit air to the condenser, and is always closed when the gages are not in use. This protecting clamp is opened first of all in starting the gage, at which time the accumulated leakage in the line is removed to the condenser and the line pressure is reduced to the condenser pressure up to the closed clamp at the gage. The mechanical rotary oil pump is started *with the by-pass cocks of the gages open*, which removes the accumulated leakage in the gage system and reduces the pressure of that system to a few thousandths of an inch of mercury absolute, once the set-up has been degassed. Each gage may then be opened to the condenser-to-gage line by first closing its by-pass cock and then gradually opening the clamp on the rubber tubing between the gage and its line to the condenser. The last operation before using the gage is to connect the plug for the condensation pump heater and the gage is ready for use after the condensation pump has been operating for a few minutes. This whole procedure is reversed when shutting down the gages.

APPENDIX

Density figures for di-n-butyl phthalate derived from a number of picnometer observations by the research laboratory of The Detroit Edison Company are to be found in Table 1.

TABLE 1 SPECIFIC GRAVITY OF DI-N-BUTYL PHTHALATE[3]

Temperature, F	Specific gravity
40	1.0562
60	1.0489
80	1.0406
100	1.0318

A check of the density of the liquid which has been used in the gages for more than a year shows a negligible change in its density. For data on the stability of di-n-butyl phthalate see Hickman's papers (3*a*, 5*b*).

At 77 F the vapor pressure of di-n-butyl phthalate is 3.07×10^{-6} inch of mercury (at the same temperature, the vapor pressure of mercury is 90.7×10^{-6} inch of mercury) (4, 5*c*). The values of the vapor pressure given by Dr. Hickman are 0.01, 0.10, and 1.00 in. of mercury, respectively, for temperatures of 259, 333, and 419 F. The melting point of di-n-butyl phthalate is —22 F at 1 atm. Di-n-butyl phthalate is not miscible with water, but will absorb gases to an appreciable extent.

The condensation pump shown in Fig. 1 is Hickman and Sanford's type AHM, (3*b*) and is used in the construction of the authors' fourth gage. Type AHN (3*c*) pump, which was used on the gages made previously, operated satisfactorily; it is nearly as efficient a pump as the former type and its fabrication is less difficult. The condensation pump and manometer are made of pyrex glass because of the heating to which the pump is subjected. Aside from the fact that a glass condensation pump is desirable for visibility of its operation, the di-n-butyl phthalate condensation pump may not be made of metal because di-n-butyl phthalate attacks metal with prolonged boiling (3*e*, 5*b*).

[3] Di-n-butyl phthalate No. 1403x, p. 26, List No. 25, twenty-fifth edition, March, 1934, of the Eastman Kodak Co., Rochester, N. Y. The specific gravities are referred to water at 4 C, at which temperature the density of water is 62.428 lb per cu ft (with standard gravitational acceleration of 32.174 ft per sec per sec).

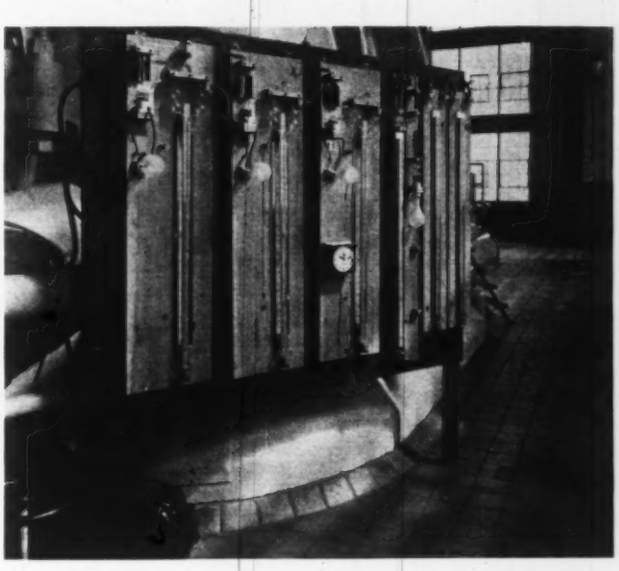

FIG. 2 ABSOLUTE-PRESSURE GAGE BOARD

(Four oil manometers are shown at the left; the two differential manometers at the right are di-n-butyl phthalate manometers for measurement of pressure differences. The rotary vacuum pump is seen at the left at the bottom.)

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Effective Handling of QUALITY COMPLAINTS

By HARRY BENSON

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IN SO FAR as the manufacturer is concerned the quality of a product is a predetermined standard of perfection based on the demands of the trade and the practical limits of manufacturing skill. The maintaining of these quality standards during manufacture is quality control. Any program of quality control should be economically sound and the savings effected should be reflected not only in dollars but in improvement in quality and reduced customer resistance.

It is the intention of the author to present briefly the methods of control as applied by a large textile organization. The complications involved in the manufacture of a diversified line of textiles may be revealed by the following partial list of manufactured products: Dress materials, cravat materials, men's furnishings, velvet materials, upholsteries and tapestries, knitting yarns, cravat manufacture, thrown yarns, dyeing, printing and finishing. The assortment of raw materials used includes silk, rayon, cotton, wool, mohair, rabbit hair, and acetates.

As a result of keen competition, modern methods, and style trends, it is necessary to keep abreast of the times and prepare for changes and improvements in the product and for the initiation of new products. The manufacturer of textiles must be guided by the customer's reaction to the product, and this reaction is rapid, because the product becomes part of one's personal attire, and likes and dislikes are immediately relayed to the manufacturer.

To attain and control the quality of the product, management has delegated certain definite responsibilities to mills, departments, and individuals under a system of functional control. Each unit or mill, such as weaving, throwing, and velvet, may be considered separately. Each mill could operate independently but it is advisable for the work to be inter-related in such a way that the finished product will be correct in every particular.

The design or specification department is responsible for the initiation and projection of new materials, and full particulars of the methods of manufacture. The quality requirements as regards washing, fastness to light, and weight are established by this department in most cases before manufacturing on a production basis is begun.

DUTIES OF QUALITY-CONTROL DEPARTMENT

The quality-control department is not responsible to the sales department or to the manufacturing department. Its function is to correlate and interpret the requests and demands of the sales organizations within the practical limits of manufacturing skill to produce an acceptable product.

This department is responsible for

(1) Establishing and maintaining practical methods for measuring quality.

(2) Maintaining information on trade requirements of quality.

(3) Preparing records of inspection.

(4) Establishing inspection stations at strategic points of the manufacturing operation in order to locate defects and prevent losses.

(5) Curtailing production on any machine or operation provided the quality is such that the curtailment is warranted. (No machines are stopped, however, without the knowledge of the manufacturing superintendent.)

In a sense the department is an agent of the customer and must be guided by the customer's requirements. It is an impartial body delegated to perform inspection operations throughout the plant and authorized to take immediate action for the correction of errors in the best interests both of the customer and the company.

The duty of the quality-control department is to anticipate by experience and common sense where accidents may be expected to occur and to prevent damages before they have caused excessive losses. The manufacture of goods should be allowed only when there is reasonable assurance that the quality will be satisfactory.

Complaints regarding quality are directed to the quality-control department. The department is responsible for making the necessary contacts with the proper superintendent or superintendents. Rigorous followups are made of all complaints to insure the satisfactory handling of the complaint.

METHODS OF QUALITY MEASUREMENT

There are many intangible factors in the manufacture of textiles, and it is practically impossible to express in writing what the eye has seen and the hand has touched. For example, one may speak of a piece of cloth as being soft. What is the meaning of "soft?" To one person it may mean the softness of fur and to another the softness of chintz. No practical scientific instruments are available for this measurement. Therefore, a small cutting made from an accepted piece is set up as a standard to which all pieces of that particular fabric are to be compared. In the judgment of the inspector, the piece is accepted provided it is similar to the standard within specified tolerances.

QUALITY-CONTROL ORGANIZATION

The quality-control department consists of a superintendent, assistant superintendent, several inspection foremen, inspectors, and clerks. Inspection stations have been established at particular points in the several manufacturing processes for the inspection of raw material, yarn in process, woven goods, and dyed goods, etc. These stations were established in order to insure the manufacture of an acceptable product. If the work at the inspection stations is executed satisfactorily, the loss on rejects is greatly reduced.

By intelligently dividing the production into quality groups of a given rating it is possible to process the goods through subsequent operations and in the final product have acceptable merchandise.

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The foreman of each of these inspection stations submits quality records to the quality-control superintendent as often as required, usually daily, weekly, and monthly. Each inspection foreman is instructed to notify the manufacturing department as soon as a defect is discovered. This constitutes the first real step in control.

The value of these reports is determined by the extent to which they are analyzed. Unless action is taken to correct the defects noted, the quality-control department becomes merely an inspection and recording unit. To function properly, the superintendent of quality control must intelligently interpret the reports and be responsible for maintaining contact with the manufacturing departments.

Staple articles may be manufactured and placed in storage in an unfinished condition for from one week to several months. Many imperfections in fabrics are not noticeable until they are dyed or printed, and for this reason it has been found advantageous to process completely a percentage of production so that the maintenance of acceptable quality merchandise may be assured.

REINSPECTION

Throughout manufacture inspectors are informed of the revisions in standards to keep them abreast of rapidly changing conditions. These men are directly responsible for the quality of goods as delivered to the customer. They are instructed to appreciate the demands of the trade and to fulfill intelligently the obligations placed on them.

It is obvious that regardless of how well the plan of inspection control is laid out that it will not run itself. Check inspection is, therefore, advisable and necessary, and this is done to the extent of maintaining inspection standards.

STATISTICAL REPORTS

Vital reports are prepared daily, weekly, monthly, and yearly for use by the manufacturing superintendents and foremen. Daily and weekly reports are usually used as guides for planning corrective measures. Monthly and yearly reports are prepared to show the trend of quality.

For this system of quality control to succeed the foremen must be convinced that the inspection reports are accurate and fair. If in one week the foreman should put forth extra effort, it is demoralizing for him to be told that the quality was poor, and if in the next week he has failed to put forth effort it is equally unfortunate on this occasion for him to be told that he has performed well. Under such conditions he cannot help but conclude that the reports are inaccurate. For this reason, too much attention cannot be given to the compiling of accurate reports. These statistical records are made as simple as possible to avoid the complication of too many reports and also in the interests of economy of clerical effort.

Enough records are prepared to reflect the quality of any given article produced. This is important because a small production of an expensive article may result in a greater monetary loss due to poor quality than a larger production of a cheaper article. A record of a small production may be entirely lost in an accumulative weekly report. It is just such cases as this that result in improved quality and economy of manufacture if they are carefully controlled.

The information reported on inspection records reflects the production figures and the three primary reasons of imperfection. The most serious imperfection heads the list, followed by the secondary and tertiary imperfections. This type of report has been found to be of more practical use than a complete report of all imperfections.

The most effective method of applying corrective measures for defective work has been found to be the concentration of efforts on the cure of the first three serious troubles. The psychological effect of applying pressure in this way reveals itself in reducing or eliminating other faults as well.

MONTHLY AND YEARLY REPORTS

Monthly and annual reports are compiled primarily as a guide to the officers of the company. The monthly reports include the individual monthly production and quality record and the cumulative record to date. As a matter of reference the record of the previous four months is also reported. Any improvement or decline in performance may readily be detected so that the proper action can be taken. Reporting the loss of the company due to defective work and rehandling is more effective if records are in dollars instead of such units as yards or pieces.

The annual report contains the totals of the cumulative monthly reports. This report affords an opportunity to reflect on and analyze not only the failures but also the successes. Intelligent plans for the future are the result of the analysis of accurate reports.

RECORDS OF DELIVERIES AND RETURNS

Quality reports to be complete should bring to light any records that disclose the reaction of the customer to the merchandise. Goods may be returned for several reasons. Analysis of the reasons for the returning of these goods has revealed important information that has resulted in modification in manufacture.

COOPERATIVE POLICY

The promotion of understanding between the quality-control department and the manufacturing departments is important to the success of quality control. As previously stated, the quality-control department must be impartial in its decisions in order to enjoy the confidence of the manufacturing and sales departments. An inspector's job is not an enviable one. He is criticized by the sales organization for being lenient in his inspection and by the manufacturing department as too critical. In one case there is resistance to sales if the quality is not up to the market standard. On the other hand if the inspector is unduly critical a large amount of defective work may result.

The quality-control department must be prepared to interpret reasonably the requirements of the trade to the manufacturing organization.

Under the present method of "hand to mouth" merchandising by the trade the delivery problem is tremendously important. Dress manufacturers, in their attempt to maintain low inventories, order materials only as required. Delays due to rehandling may result not only in dissatisfied customers but may mean the cancellation of orders as well. Delays cause losses, losses mean waste, and waste results in inefficiency.

Obviously, it should be the organization's object to manufacture its product in the most efficient and economical manner. The scheduling department naturally plays an important part. It must be assured that the time schedules for processing and the quality of raw materials are maintained. The failure of either or both of these factors may cause a break in the schedule of operations. Hence, to obtain the best results a close relationship and a spirit of cooperation must prevail among the scheduling, manufacturing, and quality-control divisions. For this reason the scheduling department must be kept informed as to the quality of materials in process, as otherwise machines may be prepared for operations for which there may be no acceptable raw material.

(*Continued on page 649*)

Quality CONTROL *in* MANUFACTURE

By FRANK J. FEELY

WESTERN ELECTRIC COMPANY, KEARNY, N. J.

THE PROBLEM of controlling quality resolves itself fundamentally into meeting the consumer's needs and desires in such a manner as best to serve his interests.

The manufacturer, in his efforts to serve the consumer, must cope with variables at all points. Materials, machines, and men are subject to fluctuations in condition and performance which influence the finished product and cause it to deviate from a desired standard. These deviations have an important bearing on the service and satisfaction which the product will render to the consumer, and from his standpoint they should be limited. However, for a given volume of production, the cost increases as the range of deviation is restricted, and it does not pay from the consumer's standpoint to go beyond the point where cost and serviceability are in proper balance.

The product designer must recognize the need for such a balance in establishing tolerances for deviation as these tolerances have an important bearing on the method of manufacture and the means used for controlling variations during production. It would require a very rigid system of control to insure perfect adherence to the established tolerances and the design should be sufficiently liberal to provide for occasional marginal departure from limits. The amount of liberality in the design must generally be restricted for economic reasons, but it may not be economical to provide sufficient margins to take care of all cases.

In practice we must therefore expect to have some cases which are not ideal from the consumer's standpoint. Such departures from the ideal may cause failures in service, abnormal maintenance cost, or reduced life of product which are important considerations to the consumer. They mean economic loss or inconvenience which should be eliminated if the added cost of providing such insurance does not more than offset such losses.

An ideal system for controlling quality should provide a means for adjusting the limitations of design and manufacturing performance in line with the consumer's experience so as to give him a maximum of satisfaction at the lowest overall cost.

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The discussion which follows is based upon experience in the Western Electric Company in the manufacture of telephone equipment. The problem of quality control in this line of manufacture is extremely complex. There is a wide range of requirements in the telephone system which calls for a large variety of product. In a single year more than 20,000 different designs of apparatus are turned out. A few types are produced in large volume but more than 80 per cent of the types have a demand below 1000 per year. Practically every piece of telephone equipment must operate in coordination with many others, and the failure of any one will interfere with the proper functioning of others. For instance it may require the making or breaking of more than two thousand electrical contacts to establish a connection between telephones located in adjacent towns. It is therefore of utmost importance to the telephone system that the product be reliable in operation and continue so over a relatively long period with a minimum of maintenance cost.

Under these conditions it is not surprising that considerable stress must be placed upon the control of quality in the manufacture of telephone equipment. There are, however, economic limitations to quality control even under such severe conditions. The problem has been greatly simplified by the close relationship existing between the consumer and the producer. This relationship permits a system of control which provides channels for complaints and relates them to quality levels used to govern manufacturing performance.

QUALITY-CONTROL SYSTEM

The diagram shown in Fig. 1 represents the general system of quality control used in the Western Electric Company. It may be divided into two main parts, i.e., that shown at the right is the overall control which correlates product design and the manufacturing performance with the consumer's experience; the control in actual production is shown at the left.

This system of control has made it possible to effect a considerable saving to telephone companies by eliminating in-

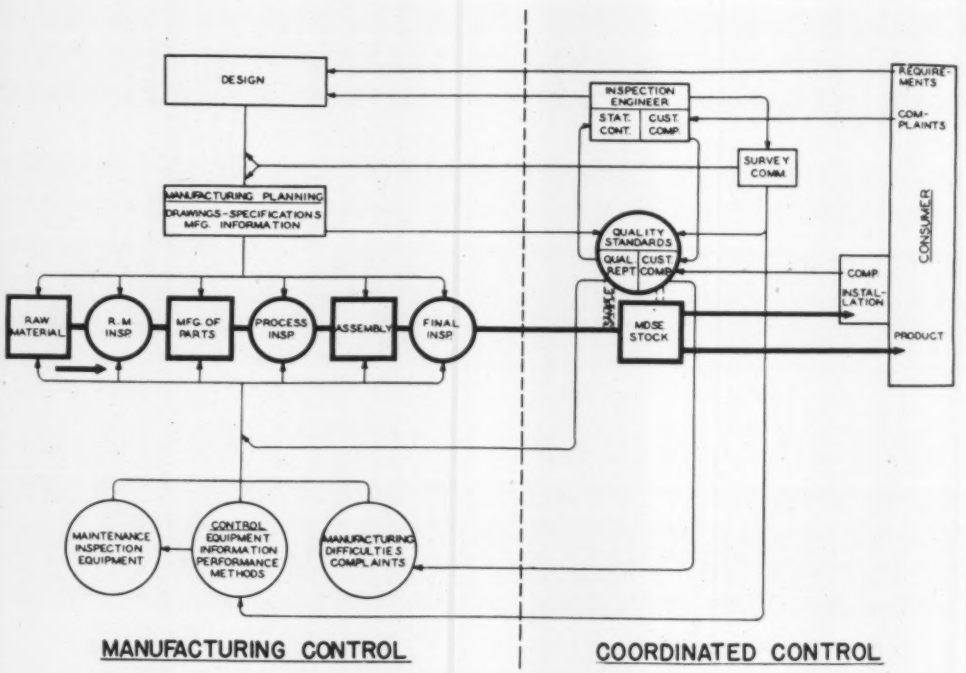

FIG. 1 QUALITY CONTROL SYSTEM, WESTERN ELECTRIC COMPANY

spection of telephone equipment on their part. As a part of the program to safeguard their interests a sampling inspection is made by an independent unit of the manufacturing organization which inspects in considerable detail relatively small samples (about 2–10 per cent) of each line of product.

The data obtained from this sampling inspection are used to present a quality picture for each line of product. For rating purposes, defects are grouped into four classes, each class having a demerit value in accordance with the degree of seriousness from the consumer's viewpoint. Any defects which are found in a given sample are assessed against the quality rating of the product in terms of demerits per unit. Charts showing performance against expected quality levels form the basis for control in the manufacturing department.

The overall control is introduced in the establishment of expected quality levels which are called "base periods." A complete study is made periodically for each product which takes into consideration manufacturing performance, complaint history, and any modification in design that has a bearing on results. The purpose of this study is to adjust levels for quality, considering all factors from an economic standpoint.

Coordination of the quality control program is made through headquarters organization by means of direct contacts with the telephone companies, complaint investigations, and by controlling the design and development of the product.

As an additional safeguard, a survey committee is set up to review periodically complaint history, quality reports, design and manufacturing information, and methods for specific items of production. The committee recommends any necessary adjustments in manufacture or design procedure.

The works inspection is responsible for exercising control in manufacture. It is organized into line and staff functions for each major production unit. The line inspection is responsible for the quality of raw material, conducts process inspection to promote manufacturing economy and to safeguard interchangeability, and judges the conformance of the completed product with requirements set for it.

The staff functions are divided into three main groups: The first maintains gages and testing equipment; the second controls methods, equipment, information, and inspection performance; the third acts as a clearing house for manufacturing difficulties and customer's complaints.

CONTROL CHARTS

Control charts and customers' complaints are used by the works-inspection units to institute necessary adjustments in the processes to control the quality levels. Fig. 2 shows a typical control chart for a product which has been kept in control for a two-year period. Limit lines based on a probability of 0.95 are located on either side of the base period. They provide for a permissible range of fluctuation due to sampling variations.

When the product is in control the plotted results on the chart will in general fluctuate about the base period and tend to average at this level. When successive results show a pronounced trend it is a definite indication that the product is getting either better or worse. Effort is made to take action when a trend is indicated and, if possible, prevent the level from going beyond either limit line.

Fig. 3 shows a product which gives definite indications of needing action for controlling the quality level. During the first four months, the product could be considered as substandard and the need for corrective action was clearly indicated. It was necessary to redevelop tools and to establish new maintenance procedure to correct the cause of the difficulty in this case. Further indications of lack of control showed up after

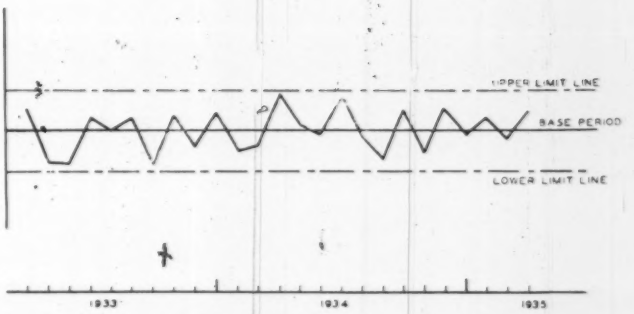

FIG. 2 PRODUCT-CONTROL CHART INDICATING CONTROL

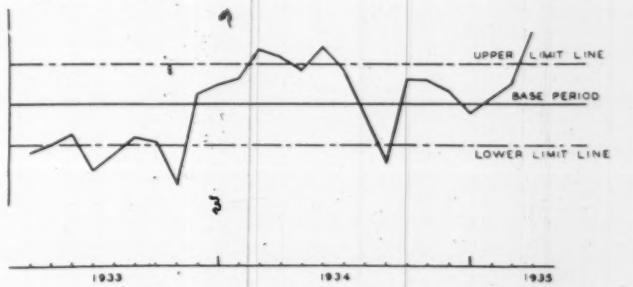

FIG. 3 PRODUCT-CONTROL CHART INDICATING LACK OF CONTROL

nine months, and at that time a comparatively minor change in procedure brought about an immediate improvement. On the last month shown, the quality level was above the upper limit line, and the general trend was upward. This indicates that economies may be effected by placing less stress on quality. It may mean that sampling inspection can be substituted for detailed inspection in the process or it may mean that equipment maintenance can be reduced, or that restrictions on the output of operators may be relaxed.

Through the use of the control charts the works inspection gets a definite indication when to look for causes which adversely affect quality. It can also determine when to promote economy by observing when the upper-limit line is being exceeded. The means of obtaining these ends by an inspection organization must necessarily vary in technique and detail. There are some lines of approach, however, which may have common application.

LINE INSPECTION'S PART IN QUALITY CONTROL

From a functional standpoint an inspection department's authority and responsibility are usually limited to the power to accept or reject at any of the various stages of the process. The control of the elements in the process which offset the quality characteristics in the product is in the hands of other departments.

The power to reject unsatisfactory work causes the departments producing this work to incur expense which shows up unfavorably in operating results and forces corrective action. This is a rather crude and expensive means of controlling quality and considerable loss is usually entailed before improvement is made. Certain penalties in the wage system serve as a check on individual carelessness. They are usually limited to nonpayment for defective work or the requirement that the workman repair the defects on his own time. These measures are only effective where the responsibility can be definitely fixed. A close adherence to functional routine provides an inspection organization with only a limited degree of quality control. In other words, inspection of the product does not constitute quality control.

QUALITY CONTROL A COOPERATIVE MATTER

An inspection organization can do effective work in securing the control of quality outside of the lines of its direct authority through the cooperative efforts of other organizations in bringing out improvements in manufacturing technique

There are two fundamental reasons why control must be exercised in the process if product of consistent quality is to be shipped to the consumer. The first is that inspection efficiency in screening out sub-standard work is something less than 100 per cent. Gages and testing equipment are not perfect and inspectors are human and therefore subject to error. When an abnormal amount of sub-standard product is produced, a certain proportion may pass through inspection to the consumer. A second and perhaps less obvious reason is that when the range of variation in the product is abnormal, there will be an excessive proportion of marginal product near the tolerances. A large amount of "border-line" product may be serviceable but usually will not be satisfactory to the consumer. This is especially true if the design has been worked up on an economical basis and does not provide liberal margins beyond the tolerances.

To secure control in the processes, it is necessary for the inspection department to enlist the support of those directly concerned, including the operating foreman, the equipment-maintenance supervisor, the planning engineer, and occasionally the designer of the product.

INSPECTION RECORDS

The approach to controlling quality, as with other problems, is simplified by having definite objectives. For each process there is always the question as to what is an economical and practical level of quality performance. As a general rule this must be worked out by experience and through considerations of service and intent of design. However, a study of inspection records and a consideration of the factors involved in a process will make it possible to set up reasonable objectives.

There will be three general classes of items which indicate need for attention: (1) Items showing a wide variation in the number of sub-normals; (2) items enough out of control to make final results questionable with average inspection efficiency; and (3) items close enough to a level of performance which would permit the use of sampling in place of detailed inspection.

The first class of items is usually affected by definite causes for variation which come into play occasionally and which, if corrected, will result in a more uniform product. The second class needs attention to protect the consumer. The third class provides a field for development in technique or process which will make possible economies in inspection effort. In each case a quality objective or bogey can be determined, which may be used as a control limit. It may be necessary to start with limits that are more or less arbitrary.

Items that exceed the established limits may then be reported as "out of control" and assigned to the individuals who are in the best position to take corrective action.

FACTORS WHICH INFLUENCE QUALITY

It will simplify the investigation of causes for variation to classify the items in accordance with the factors that have the major influence on the product.

The factors may be grouped as follows: (1) Product design; (2) raw material; (3) manufacturing methods; (4) equipment; and (5) technique.

In the simpler cases the primary causes for variation will come under one or the other of these headings. In the more complex problems, more than one factor will be involved, and there is a strong temptation to improve all factors at once. While this practice may be necessary when a general crisis is to be cleared up, it should not be followed in a systematic program of quality control because it involves excessive effort and cost. The influence of each factor should be determined by making changes only one at a time, keeping the others constant. In this way the critical factor or factors will be brought out in proper relationship so that the action taken is consistent with economic considerations.

PRODUCT DESIGN

The designer interprets the consumer's needs in the form of specifications, drawings, and even working models. It is not possible to foresee all the difficulties of manufacture; and as a check on his design, he requests tool-made samples before manufacture of the product is released. At this point the inspector is in a strategic position to forestall future quality problems, and he should give consideration to the effect of variations in raw material and in process when the tool-made sample is being made.

As the production of a given item gets under way and the output grows in volume, there will be occasions when the effort required to maintain quality could be reduced by introducing minor improvements which will make the design more foolproof. Changes of this kind not only simplify the quality problem but they also tend to reduce the cost of the product.

RAW MATERIAL

The essential requirements for raw material are usually well covered in specifications, but it is not necessary to check all shipments for all requirements. This is especially true when expensive laboratory tests are required, and it is sound business to rely upon periodic checks of materials from suppliers whose performance has proved satisfactory. Satisfactory performance would mean consistent performance with respect to specifications over a considerable period. This practice does, however, introduce an element of chance, which makes it advisable to segregate by lots the identity of critical material through processes. Such lots of raw material can then be made separate channels for investigation. Any significant variations from lot to lot give definite clues for working out improvement.

The development of new sources of supply for material introduces great possibilities for difficulty from a quality standpoint. The first shipments will usually be checked thoroughly for all stated requirements. The runnability of this new material should be checked by introducing a sample into the process as soon as possible to avoid delay and possibility of shut-down later. Where critical factors are involved, samples of finished product containing the new material should be submitted to intensive tests under adverse conditions. In spite of all these precautions, there may be inherent properties in the new material that are covered only in general terms in the specifications and which may cause trouble later. It is therefore advisable to earmark by dates or other means of identification the product that contains this material.

In some cases it pays to maintain charts showing each supplier's performance with respect to certain key requirements. An effort should then be made to get each supplier to furnish material near the mean of the tolerance. This will help to maintain more uniform results in the manufacturing processes.

MANUFACTURING METHODS

The manufacturing methods used for any given product must be planned from the standpoint of overall economy. Where the volume is low or the demand is uncertain, it does not pay to put much refinement into the equipment or the process. Under such conditions limitations in plant investment make it

advisable to use simple tools and equipment. The product turned out by this equipment is often subject to considerable variation and is difficult to control from a quality standpoint. It may be necessary to add operations which were not considered in the original planning. A refinement of tools may prove to be more economical, but it must be clearly justified by saving in inspection labor, reduced scrap losses, or improved quality.

On large running items it is extremely important that uniformity be maintained in the process to avoid the development of "spotty" conditions. A typical example of this developed in connection with the terminals that are crimped on the ends of telephone cords. Each terminal has sharp prongs which pierce the stranded conductor to make electrical contact. It is important that good electrical contact be made. The expense of detailing for this defect would be prohibitive and control is maintained by statistical sampling. The terminals are checked by running samples of each lot on a crimping tool which is maintained for test purposes. Each crimping tool is checked by daily samples of the product. These checks showed a pronounced variation in the quality of the terminals. The primary cause for variation was due to the gradual wear in the perforating punches which formed the prongs. It was necessary to incorporate in the tools used for making the terminals a means for swaging which sharpened and straightened the prongs. Since this change was made, a much more uniform product has been obtained.

Items which are produced in large volume are subject to considerable change in methods through the cost-reduction activities of development engineers. This is especially true in the manufacture of telephone equipment where the product itself is under intensive development at all times. With each change in method the quality problem assumes new aspects, and it is important that the inspector and the engineer work together when changes are introduced.

EQUIPMENT

When considering any operating equipment as a factor in quality control there are usually four points that should be given consideration: (1) Setup, (2) method of operating, (3) maintenance, and (4) design, taken in order.

It is of importance to determine the direction and the extent of wear or change of adjustment. The equipment should be set up with this trend taken into consideration to insure a production of parts near the mean of their tolerances. This is especially true in the manufacture of interchangeable parts. Trouble is often encountered in assembling associated parts that are produced near the extreme of their tolerance and where the combination is unfavorable.

The machine operator, when provided with suitable gages or measuring devices, is in a strategic position for quality control from the standpoint of tool wear and machine adjustment. He is also in an excellent position to detect inferior quality of raw materials going into the machine in many cases, and he should understand that this is definitely part of his responsibility. Some equipment needs to be operated with due consideration to certain fine points of control to secure best results. These are matters that should receive thorough attention while the operator is being trained, but it occasionally becomes necessary to stress them with experienced operators.

The condition of equipment bears an important relation to the quality of product turned out. Unless maintenance effort is directed specifically to quality performance with respect to the product, this important consideration may be overlooked, and the attention will be centered on purely mechanical matters. Equipment may be turning out sub-standard work long before it is ready to break down. The critical points from a quality standpoint should be determined for each piece of equipment, and a basis should be worked out for systematic attention.

A great deal of equipment in modern industry is of special design. It is difficult for the machine designer to anticipate all factors which would affect the quality of the product. There is a limit to the amount of refinement that is warranted, but where an abnormal amount of defective work is produced and where the cost of inspection is a considerable factor, the economics of the situation may justify further development of the equipment.

TECHNIQUE

In operations requiring specialized training or job knowledge the skill of the individual worker plays an important part in quality performance. A typical example of this is the soldering of wires on terminals. In telephone work all electrical connections are soldered, and because of the intricate circuits involved the failure of any connection may cause a great deal of trouble. It is therefore necessary to demand very high standards of soldering performance, and great emphasis has been placed on training programs and on the standardization of methods. In spite of these efforts there is a considerable range of performance due to the difference in the aptitude of individuals and the extent of their experience.

During build-up periods the technique factor predominates in the quality problem. Operations that demand a high degree of skill and technique will be subject to considerable variation as the load is built up due to the influx of new people who must be trained and put to work as soon as possible. Whenever it is possible and practicable the output of the new people should be segregated from that of the experienced operator. If their work is mixed indiscriminately, the general quality level deteriorates and the morale of the entire force is likely to be affected. It is highly important that definite quality levels of performance be established for training and development purposes. Individual quality ratings for new people also help to develop operators and assist in the problem of control.

Segregating the work of old operators into groups or by individuals according to the quality of work may be of equal importance. Efforts can then be directed toward improving performance where the work is not up to the required level. Individual quality ratings of experienced people will also tend to keep the organization toned up from a quality standpoint.

Spasmodic efforts at improving quality have a serious effect on costs. These can be avoided by systematic pressure in the spots where improvements are required. Quality can be overstressed and output and efficiency be made to suffer thereby. Records of performance in relation to definite quality levels will tend to obviate this.

SAMPLING INSPECTION

As the control program on any item of manufacture proceeds, the more obvious causes for sub-standard work will be eliminated and the variations will be less pronounced. If the control level has been set too low, it will become increasingly difficult to find and correct causes for exceeding the limit for defects. The attention will be directed more and more to the economic factors involved, and it will be found that some changes are not worth making. The control should then be adjusted to the economical level. A further refinement will involve the establishment of a range for variations about this control level.

When a quality characteristic is brought into control the possibilities for sampling inspection to replace detailing should be considered. Where sampling has already been in use, the

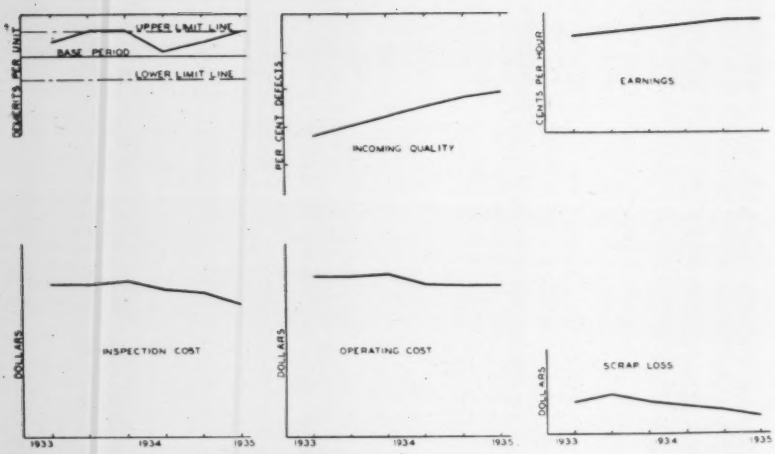

FIG. 4 PERFORMANCE, PRODUCT *A*

improvement in quality will make it possible to reduce sample sizes. The choice of a sampling method which will give the best control at the lowest cost must be adapted to each process.

Needless to say, the use of sampling makes possible considerable saving in inspection costs, and this represents one of the major economies effected through a quality-control program. There will usually be further savings due to reduced scrap losses and repair costs. Such a program will often bring about more systematic methods and fewer interruptions to production, which tend to improve the earnings of operators and provide for more economical production.

RESULTS FROM A QUALITY-CONTROL PROGRAM

The following two cases are cited to illustrate the benefits which have been derived from a program of quality control in certain lines of telephone equipment during the last two years.

In the first instance the product was being turned out in considerable volume. A number of changes had been made in methods and equipment, and while the overall quality rating of the outgoing product was satisfactory, there was enough variation in individual quality attributes to warrant intensive development. There were four general classes of defects investigated because they were higher than the control limits which were established for the items involved. Relatively simple refinements were incorporated in some of the machinery, and minor changes were made in maintenance practices. Modifications were also made in operating procedure, in raw material, and in process specifications.

The results obtained are shown graphically in Fig. 4. Scrap losses were reduced about 50 per cent. Operating labor costs were reduced about 6 per cent and inspection labor costs were reduced 12 per cent. Average earnings for operators had increased about 15 per cent, due in part to higher wage scales, but increased productivity also played a part.

The present outgoing quality level is above the economical point, and it is estimated that an additional saving of 10 per cent can be made in inspection costs by further application of sampling, and still maintain a satisfactory level of quality.

In the second case, the product involved requires a great deal of technique and skill. It is a line of product that is relatively expensive to inspect and difficult to control. The demand had been brought down to a low level and the operating force reduced to include only former supervisors who had not performed the actual work for several years. It appeared to be an ideal opportunity to establish a good foundation of quality control for future expansion in an important line of product.

Control levels were established which would make it possible to eliminate detailed inspection for some items. Performance records were kept for separate groups and in some cases for individuals. The results for a period of eighteen months are shown in Fig. 5. During this period the cost of operating labor was reduced 7 per cent, although average wages had increased by 5 per cent. Inspection cost was reduced 50 per cent. The results for the last six months show that the trend of costs is slightly upward and indicate that quality has been stressed beyond the economical point. There are, however, possibilities for further reductions in inspection costs, which can be effected if suitable statistical control can be applied. This involves further study of performance by individuals which is now under way.

In both examples given, the return in actual savings of operating and inspection costs has well justified the effort applied. In addition, more uniform product has resulted from the control program which will undoubtedly give the consumer better service, and at the same time the workers have earned more money. In other words, the desirable goal has been obtained which comes about from planned effort which produces advantages to the public, to the worker, and to the owner of the business.

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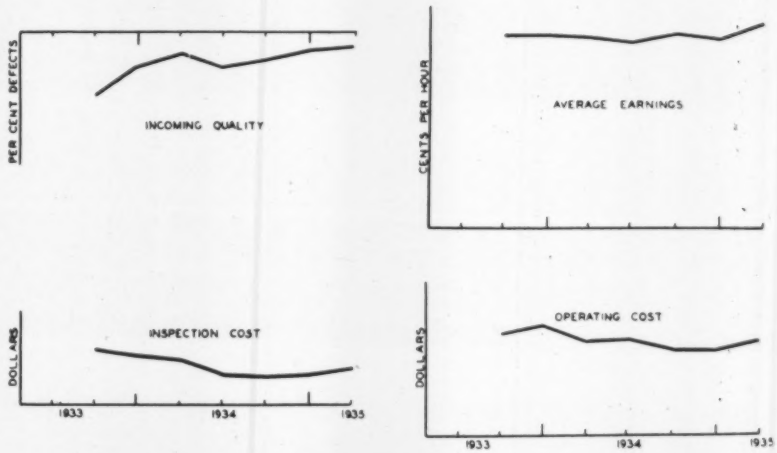


FIG. 5 PERFORMANCE, PRODUCT *B*

Inspectors' Errors in QUALITY CONTROL

By J. M. JURAN

WESTERN ELECTRIC COMPANY, CHICAGO, ILL.

IN ANY discussion of quality control it must be recognized at the outset that the source of all information concerning quality is derived from inspectors, human inspectors. It follows from this that "quality" as portrayed by the inspector or by results derived from the inspector differs from the facts more or less. In other words, there is a difference between the *true quality* and the *picture of true quality* because human beings present this picture.

In his paper on "Quality Control in Manufacture," Mr. Feely has pointed out that the factors influencing quality may be grouped as follows: Product design, raw material, manufacturing methods, equipment, and technique.

It must be clear, however, that the summation of the effect of these which we call quality is nevertheless measured by a human inspector. It is therefore of considerable importance to consider the manner in which the fallibility of the inspector can arise. To do this, we shall run through several instances showing either involuntary or deliberate errors by the inspector. For the purpose of general classification, inspectors' errors can be divided into:

(*a*) Errors in reading measuring instruments
(*b*) Errors in judgment
(*c*) Errors in recording.

As previously stated, these errors may be involuntary or deliberate. It becomes necessary for us to resign ourselves to some degree of involuntary or unavoidable errors. However, it is well to consider means of distinguishing involuntary errors from the deliberate since the latter are avoidable.

Fig. 1 shows spring tension readings taken by an inspector. Obviously his gage reads to five-gram lines and his tension limits are 38 to 48 grams.

Fig. 2 shows measurements of characteristics on telephone receivers. The favoring of even values clearly points to a scale graduated in divisions of 2. The maximum limit is undoubtedly 30, as evidenced by the lack of readings slightly larger than this.

Undoubtedly in both the cases cited there are two tendencies present; the first is a tendency to crowd observations around the scale graduations. This is partly psychological—a human way to read a scale and partly the result of trying to make speed—guessing at the reading. The other tendency is far more important—a tendency on the part of the inspector to lean in one direction when the product is close to the acceptance boundary. Such tendency may be very serious and should be closely observed. When an inspector calls something within just because it is only slightly outside, he is taking it upon himself to set the limits which ought to be set by an engineer.

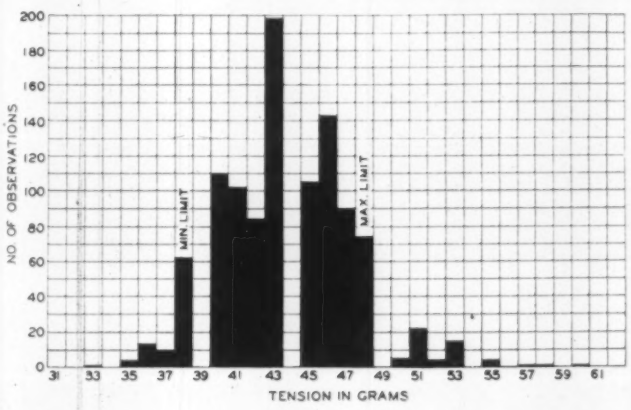


FIG. 1 SHOWING HOW DISTRIBUTION OF INSPECTOR'S OBSERVATIONS ARE AFFECTED BY A GAGE READING TO 5 GRAMS INSPECTING SPRING TENSION OF SEQUENCE SWITCHES

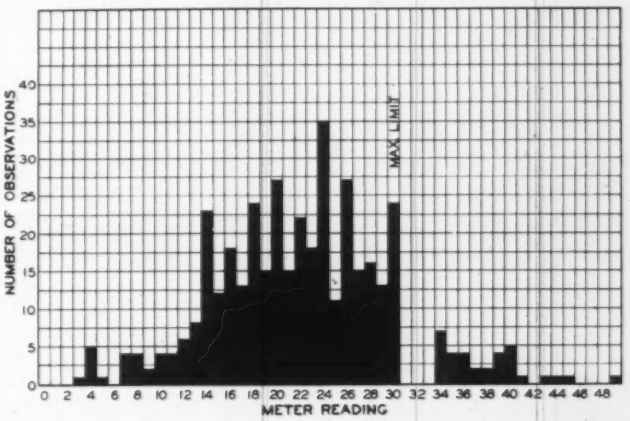


FIG. 2 SHOWING HOW EVEN VALUES ARE FAVORED BY USE OF A SCALE GRADUATED IN DIVISIONS OF 2 AND HOW INSPECTOR HAS A TENDENCY TO LEAN IN ONE DIRECTION NEAR LIMIT IN INSPECTING VOLUME EFFICIENCY OF RECEIVERS

Figs. 3 and 4 are examples of a different sort. They occur in attribute inspection and the number being determined by the inspector is the number of defects present in a sample of a given size. It is obvious that the inspector is somehow getting a weird result. If he is doing this by going back over the defects and calling doubtful cases good, the procedure may be satisfactory. If he is deliberately ignoring the presence of enough defects to make the lot acceptable on a sampling basis, his performance is subject to serious censure.

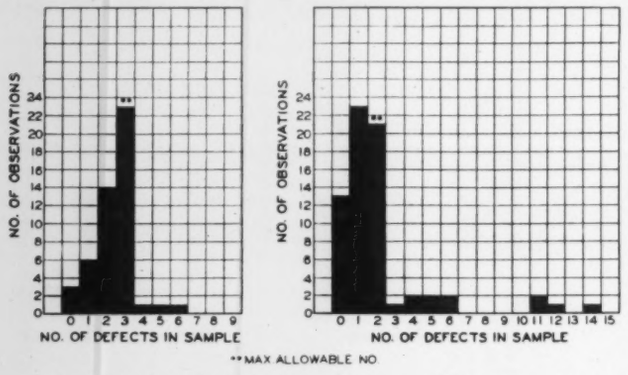
Figs. 5 and 6 show a still different example. Here the inspector for some reason is desirous of taking a second sample. The shape of the distribution of defects found in the second samples looks reasonable and is undoubtedly the true picture of conditions. The picture shown by the results in the first samples is clearly false and an investigation is necessary to see what is causing the inspector to produce such a surprising result.

HOW ACCURATE ARE INSPECTORS IN FINDING DEFECTS?

An answer to the question, How accurate are inspectors in finding defects? may be obtained by reinspecting part of the inspector's work and properly treating the results. Some important principles must be observed, chiefly that the performance of the inspector can be determined only by his judgment of defective parts—not that on good parts. It is a decided effort to identify defectives, but not to identify good

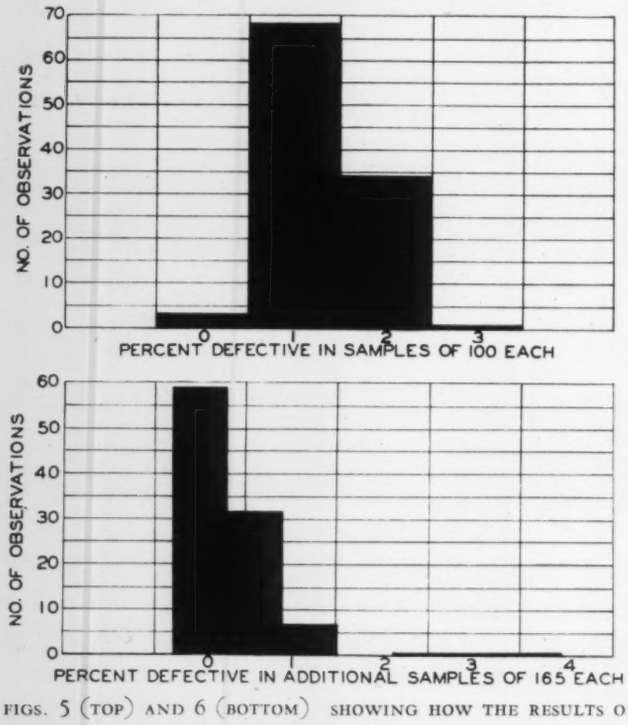
material, or, as classically put, "Any fool can inspect good work."

To judge from the defects, it is necessary to compare the defects found by the inspector with the total defects present, those not found by the inspector being found by some experi-



(Fig. 3 Defects allowed 3.) (Fig. 4 Defects allowed 2.)

FIGS. 3 (LEFT) AND 4 (RIGHT) SHOWING HOW INSPECTOR IS APPARENTLY INFLUENCED BY "ALLOWABLE" NUMBER OF DEFECTS



FIGS. 5 (TOP) AND 6 (BOTTOM) SHOWING HOW THE RESULTS OF INSPECTION OF FIRST SAMPLES WERE CAST IN DOUBT BY RESULTS OF INSPECTION OF SECOND

enced man delegated to check the work of the inspectors. In other words, the accuracy of the inspector becomes

$$\text{Percentage of accuracy} = \frac{\text{Defects found by inspector}}{\text{Defects present in material}}$$

A plan of this sort was installed in the Hawthorne plant of the Western Electric Company in 1921 and has functioned successfully since. The percentage of accuracy since that time has risen from less than 85 per cent to more than 97 per cent.

Fig. 7 illustrates how the percentage of accuracy is determined. If D is the number of cases reported by the inspector as defective (45, for example) and K is the number of cases reported by the inspector as defective but actually not defective (say 5), then $D - K$ will be the number of true defects identified by the inspector (40 in this instance). Now suppose B is the number of defects *missed* by the inspector but found by the "quality inspector" in his checking of the former's activity (10, in this example). Then $D - K + B$ will be the number of defects originally present, or the sum of those found by the inspector and those missed by him (50 in this case). Hence

$$\text{Percentage of Accuracy} = \frac{D - K}{D - K + B} = \frac{45 - 5}{45 - 5 + 10} = 80$$

per cent. This represents the percentage of defects correctly

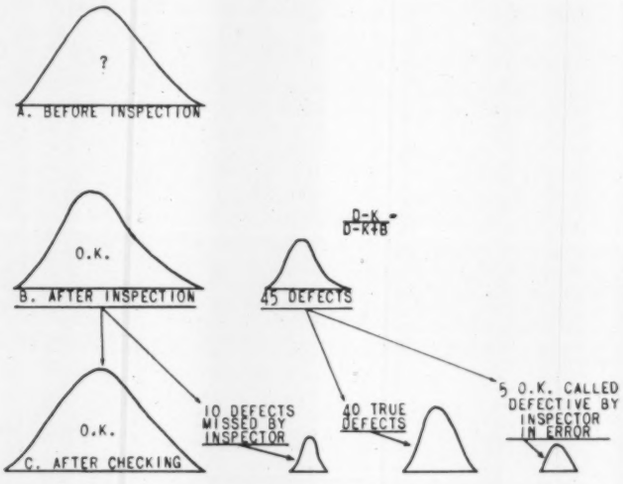


FIG. 7 DIAGRAMMATIC REPRESENTATION OF PROCESS OF ARRIVING AT PERCENTAGE OF ACCURACY OF INSPECTORS

identified by the inspector, or the ratio of those he found to those that were to be found.

IMPORTANT PRINCIPLES EMPHASIZED

Two points made by Mr. Feely, seem to me to be outstanding because of their great truth. The first is that

> The machine operator, when provided with suitable gages or measuring devices, is in a strategic position for quality control from the standpoint of tool wear and machine adjustment. He is also in an excellent position in many cases to detect inferior quality of raw materials going into the machine, and he should understand that this is definitely part of his responsibility.

Modern thought is almost unanimous in the realization that we cannot inspect quality into product. The quality must be there before it comes to the inspector.

The other point is as follows:

> Spasmodic efforts at improving quality have a serious effect on costs. These can be avoided by systematic pressure in the spots where improvements are required. Quality can be overstressed and output and efficiency be made to suffer thereby. Records of performance in relation to definite quality levels will tend to obviate this.

A common analogy would be an idea that fire departments should wait for a fire, put it out, and then wait for another, instead of applying the steady hand of fire prevention. Too frequently we have seen an inspection group grow lax in vigilance until a complaint from the customer wakes them up. They promply swing the pendulum a full stroke in the opposite direction, and the factory groans in its effort to meet the now unreasonable demands. A sound and steady control, like a sound currency in commercial relations, gives the factory foremen a feeling of confidence and gives the consumer a feeling that control is being exercised before the product reaches him.

Statistical Aspects of SAMPLING INSPECTION PLANS

By H. F. DODGE

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IN HIS paper on "Quality Control in Manufacturing," Mr. Feely has indicated that unless and until quality of parts or of finished products turned out by an operating department is maintained at a level which is satisfactory for use in subsequent operations, a 100 per cent screening inspection may be necessary to sort out the pieces which fail to conform with requirements. He indicated further that if quality turned out in process is well controlled at a suitable level, 100 per cent inspection may give way to a sampling inspection, and considerable savings in inspection cost may be realized.

Some of the statistical aspects of the problem of setting up economical sampling inspection plans are discussed in the following paragraphs.

INSPECTION BY METHOD OF ATTRIBUTES

First, consider inspection by the method of attributes. In what follows, the word "defective" is used to denote any deviation from a specified requirement or from accepted standards of good workmanship.

A general plan of procedure to provide a minimum amount of inspection when the product consists of discrete lots has been outlined in a paper[1] published several years ago. As therein indicated, the solution of the problem may be based on two requirements:

(1) That there shall be provided a definite insurance against passing a lot of unsatisfactory quality. The border line between satisfactory and unsatisfactory quality is given a numerical value by establishing a "tolerance for defects," such as 1 per cent, 2 per cent, 3 per cent, and insurance is expressed in terms of a "consumer's risk" whereby, for example, a lot of tolerance quality is given but one chance in ten of being accepted.

(2) That the total amount of inspection for product of normal incoming quality shall be a minimum. This "total" consists of the number of pieces inspected in samples plus the number of pieces in the balance of those lots which are inspected 100 per cent as a result of failure to be accepted on the basis of the sampling results.

Figs. 1 and 2 indicate the solution for the specific case where it is desired to set up a single sampling plan that will involve a minimum amount of inspection for lots of 5000 pieces each, where the incoming quality averages one-half of one per cent defective (process average = 0.5 per cent). The first requirement of a 10 per cent risk for a 3 per cent defective lot is met by several combinations of sample sizes n and allowable number of defects in sample c, as shown in Fig. 1. Fig. 2 shows that the most economical sampling plan is provided by taking the combination $n = 265$ pieces and $c = 4$.

In practice, it is most convenient to set up tables which make it possible for the inspection engineer to select that table which will insure a minimum inspection for a given set of conditions, that is, for a given tolerance for defects, a given consumer's risk, a given lot size, and a given process average quality.

In continuous production on a large scale, interest may not

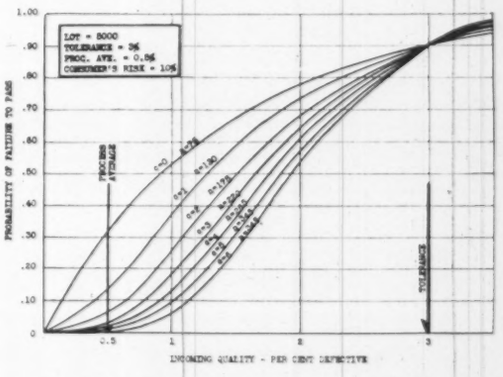

FIG. 1 SHOWING PROBABILITY OF FAILURE TO PASS

center on individual lots and it may be desired to insure that the percentage of defectives passing on to the next stage will automatically be restrained to some desired low value, such as 0.1 per cent, 0.5 per cent, or 1.0 per cent. Under such cir-

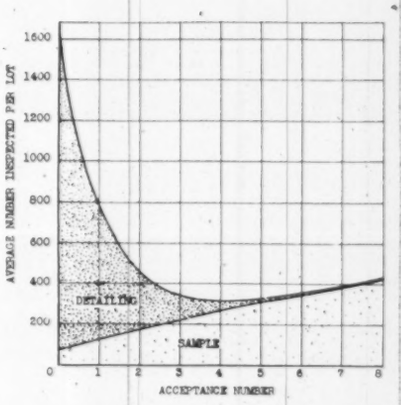

FIG. 2 SHOWING AVERAGE AMOUNT OF INSPECTION PER LOT FOR PROCESS AVERAGE QUALITY

cumstances, what are considered as lots may be quantities that are designated as lots merely for convenience in handling. Here again, if it is desired to establish a sampling plan that will insure a minimum amount of inspection and at the same time guarantee that the outgoing quality will be held to some economical level, theory enables us to set up tables which will provide a plan of procedure embodying these desirable features. Table 1 is a sample of a set widely used for this

[1] "Method of Sampling Inspection," by H. F. Dodge and H. G. Romig, *Bell System Technical Journal*, October, 1929, pp. 613–631.

purpose. This table is based on a double-sampling scheme in which

n_1 = number of pieces in the initial sample
c_1 = allowable number of defects in the initial sample
n_2 = number of pieces in a second sample which is taken if the lot fails to pass on first sample
c_2 = total number of defects allowed in the first and second samples combined.

If the requirement c_2 is not met, the lot is inspected 100 per cent. The use of this table would guarantee that, no matter what the incoming quality might be, the average out-going quality would not exceed 0.5 per cent defective. Maximum economy of inspection effort is obtained by determining from current performance records the average incoming quality (process average per cent defective). For example, if the process average were within the band 0 to 0.1 per cent, the plan at the left of Table 1 would be used, whereas if the process average were within the band 0.21 per cent to 0.30 per cent, the plan at the right would be used. Complete tables include, of course, all possible values of process average. The column to the right of each table with the caption, "p_t %," indicates the associated values of "per cent defective in lot" for which the consumer's risk of acceptance is one in ten. This column serves as a guide to choice among several alternate tables, where it is desired to maintain control over the range of quality for individual lots or shipments. The reduction of theory to tables of this sort is important in practical work for it provides exact procedures to be followed by the shop inspector.

TABLE 1 DOUBLE SAMPLING LOT INSPECTION—METHOD OF ATTRIBUTES

(Average outgoing quality limit = 0.50 per cent)

Process average per cent Lot size	0–0.10 Trial 1 n_1	c_1	Trial 2 n_2	n_1+n_2	c_2	p_t %	0.21–0.30 Trial 1 n_1	c_1	Trial 2 n_2	n_1+n_2	c_2	p_t %
1–50	30	0	...	...	..	5.0	30	0	...	...	...	5.0
51–100	50	0	20	70	1	4.2	50	0	20	70	1	4.2
101–200	70	0	30	100	1	3.5	70	0	30	100	1	3.5
201–300	80	0	40	120	1	3.1	80	0	40	120	1	3.1
301–400	85	0	45	130	1	3.0	85	0	45	130	1	3.0
401–500	90	0	50	140	1	2.9	90	0	50	140	1	2.9
501–600	95	0	50	145	1	2.8	95	0	50	145	1	2.8
601–800	100	0	55	155	1	2.7	115	0	120	235	2	2.3
801–1000	105	0	55	160	1	2.6	125	0	125	250	2	2.2
1001–2000	115	0	70	185	1	2.4	140	0	215	355	3	2.0
2001–3000	120	0	70	190	1	2.3	145	0	235	380	3	1.9
3001–4000	135	0	150	285	2	2.2	165	0	335	500	4	1.8
4001–5000	140	0	160	300	2	2.1	165	0	340	505	4	1.7
5001–7000	140	0	160	300	2	2.0	275	1	425	700	6	1.6
7001–10,000	145	0	160	305	2	2.0	280	1	420	700	6	1.6
10,001–20,000	150	0	240	390	3	1.9	305	1	535	840	7	1.5
20,001–50,000	160	0	250	410	3	1.8	330	1	760	1090	9	1.4
50,001–100,000	170	0	265	435	3	1.7	330	1	860	1190	10	1.4

INSPECTION BY METHOD OF VARIABLES

So far, we have considered only inspection for defects. Greater dividends in the form of savings in inspection costs are realizable in the inspection of variable characteristics, particularly those for which sampling is unavoidable. This situation arises when the cost of a measurement is high or where inspection or testing is destructive. Fig. 3 indicates three such characteristics. Here, the inspection data consist of numerical values obtained in samples of several individual pieces or test specimens. In considering acceptance or rejection of product, data so obtained may be treated in one or two ways: (1) By merely counting how many observations fall outside limits specified for the piece (method of attributes), and (2) by taking into consideration the distribution of observed values, using such statistics as the average and the standard deviation (method of variables).

Time does not permit a detailed discussion of this problem though it is perhaps of interest to note that by employing the method of variables in analyzing and interpreting data, one may secure the same efficiency of discrimination between satisfactory and unsatisfactory quality by taking only one-half to one-third as many observations as would be necessary were the inspector merely to count the number of observations falling outside the limits specified. A typical acceptance requirement is indicated in Fig. 4, whereby acceptance is based upon a consideration of the average in the sample and the "range" (difference between the largest observed value and smallest observed value). Using such a criterion, a lot is accepted if the observed value of average and of range (represented by a dot on this diagram) falls below the slant line. In this particular case, a sample of eight or ten specimens would be required to give the same degree of protection to the consumer if the acceptance requirement were to be based on an allowable number of observations falling below the minimum limit prescribed for a test specimen.

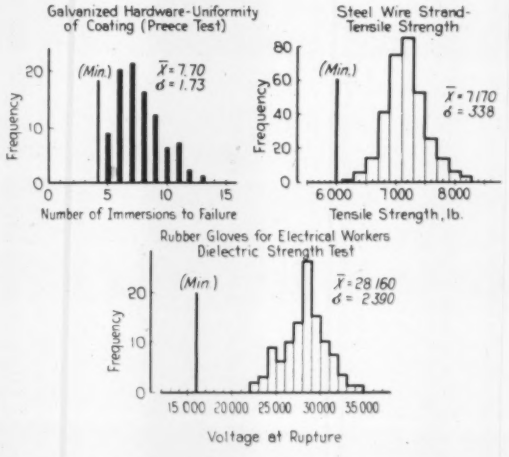

FIG. 3 TYPICAL QUALITY CHARACTERISTICS FOR WHICH 100 PER CENT INSPECTION IS NOT POSSIBLE

(Fig. 3 is a reproduction of Fig. 1 of "Acceptance-Rejection Requirments in Specifications," by H. F. Dodge, Proceedings, A.S.T.M., vol. 34, part 2, 1934, pp. 877–890.)

Acceptance requirements of this sort are being used more and more widely in practice and substantial economies in inspection effort are being derived by more efficient use of data in this way.

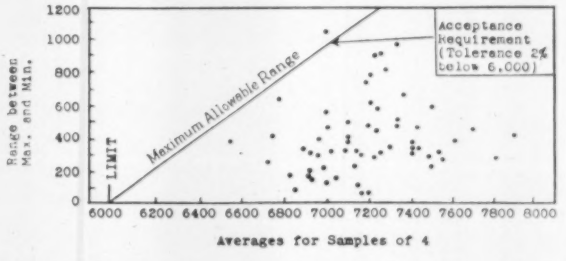
Range between Max. and Min.
Maximum Allowable Range
LIMIT
Acceptance Requirement (Tolerance 2% below 6,000)
Averages for Samples of 4

FIG. 4 AN ECONOMICAL ACCEPTANCE REQUIREMENT USING THE METHOD OF VARIABLES

The ENGINEER *and the* HOUSING PROBLEM

By E. S. BURDELL

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ONE might say concerning housing what Mark Twain said about the weather, "It is a much discussed subject about which very little is ever done." And one might add that housing is a topic upon which there is usually more heat than light. While there are minor disagreements as to type of construction and building materials, the bulk of the arguments revolve about the social and economic factors involved in the government's participation in a field of enterprise which in the United States has been wholly identified with private initiative, private capital, and private control. For any engineer to hold that this state of affairs is to persist always in a country where federal, state, and local governments are becoming the largest single employer of his profession is to be blind to realities and the victim of wishful thinking which is unworthy on the part of those trained in the natural sciences and technology. It is a strange commentary on engineers that as a profession it is the most eager to seek improvements, to innovate, to scrap outmoded machinery and techniques, yet when individual engineers come face to face with a new social or economic situation they too often do several peculiar things. One is the ostrich act of burying their heads in the sands of the past and unreservedly saying that certain details of a system that were good enough for their great-grandfathers are good enough for them, even though sailing vessels and canal boats aren't. Another minority group in the engineering profession go the way of the Technocrats. This group usually does not concede anything authentic in the literature of the social sciences. Economics, political science, history, psychology, and sociology are fields of sober thought that have enjoyed the benefit of a century or more of quiet and careful investigation. They joyfully hurdle these for the more alluring pastures of the marahuana weeds of "pure" speculation. The deluge of pamphlets, tracts, and articles of "single-track" ways out of the depression and up into the Elysian fields of a Utopia are submitted in evidence of the gyrations of this group. In justice, however, to the great bulk of the engineering profession it must be said that they are eager for information and for ideas on subjects that are not strictly in their own line of work. This series of articles on economic and social topics is ample evidence.

RECOMMENDED READING FOR ENGINEERS

These comments are referred back and tied into one of the best books on the subject of housing called "Modern Housing," by Catherine Bauer,[1] published in 1934. Miss Bauer, whose father, is a former New Jersey state-highway engineer, had the advantage of financial assistance from the Carnegie Corporation in the collection of first-hand data from a European tour in the preparation of this book. This reviewer heartily recommends it to the engineering profession in that facts, ideas, history, and theories are woven into a comprehensive whole that is as entertaining as it is informative and provocative.

The main body of the text of 250 pages is divided into four parts in a logical and chronological scheme in which the subject of housing is painted against the contemporary background of the times. The nineteenth century, in so far as housing is concerned, is branded by Miss Bauer as a failure. As she so cogently phrases it, "It must always remain one of the great historic ironies that the century which invented the notion of material Progress, which unfolded more scientific possibility than all the preceding years of western civilization put together, was also the century which debased human environment to about its lowest known level. If a civilization is 'the use to which an age puts its resources of wealth, knowledge, and power in order to create a social life,' then the nineteenth century as a civilization is a record of failure."

EFFECTS OF INDUSTRY ON HOUSING

Steam as a source of direct power inevitably led to huge concentrations of machines into factories. And factories, instead of spreading themselves thin over the countryside, grouped together in the towns. But the trouble was that the towns had no experience in furnishing a water supply, a sewage-disposal system, a system of laws and law enforcement. They actually found their population doubling every few years and the problems of urban living increasing four- or fivefold. "The average dwelling of the average citizen was narrower, darker, dirtier, and more crowded in the prosperous middle decades than it had ever been before. And if it was a trifle more sanitary in some instances by 1900 this advantage was balanced by far less accessibility to work places and play places and open country and by greatly increased rents." Lest readers may think these statements are slightly overdrawn, I recommend that they read the quotations given in the first chapter by Miss Bauer from contemporary nineteenth-century writers. As late as 1885 a Paris judge held that for a landlord to be compelled to install water in his tenements for the use of his tenants was an interference with his liberty. It was held that a water supply was not an indispensable necessity for health! However, cholera epidemics and the civil uprisings of 1848 and 1870 did more to add sewers, water supply, paved streets, and factory and housing regulations than any of the high sounding platitudes of societies for improving the conditions of the poor. It is significant in this connection that it was under the Tory governments of England and the Junker power in Germany that substantial progress was made in ameliorating the conditions that threatened the safety of the state and incidentally the stability of their class. However, the ostentatious boulevard building of Napoleon III and his architect

[1] "Modern Housing," by Catherine Bauer. Houghton Mifflin Co., New York, 1934. 322 pp., with appendix and bibliography, 200 illus., $5.

Seventh of a series of reviews of current economic and sociological literature affecting engineering prepared by members of the Departments of Economics and Sociology, Massachusetts Institute of Technology, at the request and under the sponsorship of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Haussmann could hardly be said to improve living or housing conditions in Paris. The congeries of twisting murky alleys and cul-de-sacs remained after the broad, straight, and tree-planted boulevards had been completed. In many American cities today that the reviewer might mention, the civic center or the station plaza stands as the community's sole expression of utility combined with art and beauty. They are the direct descendants of the City Beautiful movement engendered by the Columbian Worlds Fair in Chicago in 1893 which in turn might claim the Second Empire and the Paris Expositions as its ancestors. Up to that time the American city was the place where competitive business held full sway and no sob-sisters or "arty" visionaries were to make demands of unbusinesslike cooperation or of self-restraint.

Part 2, "Gathering Forces," traces out swiftly and in bold relief the development of ideas relating to housing reform, starting with Robert Owens, William Morris, the Chartist Movement, Lord Shaftsbury, Ebenezer Howard, and ending with Patrick Geddes, and Raymond Unwin. Engineers will find interesting the chapter concerning Robert Owens' planned community of 1818 and Charles Godin's actual community for the housing of workers of his stove factory at Guise, France, in the 1850's.

In the following chapter, "The Heyday of Paternal Reform," Miss Bauer makes the challenging statement that this reform movement failed primarily because all the building projects must pay for themselves. "There were four factors in building economics which the reformers, almost to the last man, accepted as acts of God which it would be unmoral and subversive even to question. One was the price of land, however fantastic the level to which speculation and previous unregulated congestion might have brought it. The other factors were the high rate of return on the investment, the importance of private capital and private initiative as the sole agency of reform, and the insistence that if working men can't pay for the new facilities thus provided they probably don't deserve them. . . . Any suggestion of a subsidy as an indirect means of raising real wages or a direct means of building decent and livable cities was sure to raise a furor of horror and consternation."

PLANNED CITIES

The various municipal policies toward housing are discussed in an interesting way and Miss Bauer cogently contrasts the German city to the American city when she says that the American city does only what it is permitted to do, while a German city does everything except what it is forbidden to do. She points out also that scientific management of cities developed first in Germany as far back as 1890 and that city planning as we know it was already in full swing in Germany in 1900. The legal doctrine of "lex addickes" whereby urban land could be pooled and replanned is credited to Herr Addickes, the Mayor of Frankfurt in 1902. This is of far-reaching significance to housing throughout the world, for it solved the hitherto formidable problem of mass housing on a large scale within the confines of a congested area where land titles were held in fractional parts and one owner could obstruct effectively by holding out and refusing to sell some small parcel that might be indispensable to the project.

Engineers who have read much about garden cities and garden suburbs will find a detailed and interesting account of the original garden cities of Letchworth and Welyn and the basic ideology of limitation of size, indigenous employment, and public ownership of land or control by a self-governing corporation. How far a cry this is from the so-called American garden suburbs of Radburn, New Jersey, or Mariemont, Ohio, is evident. Both are merely glorified bedrooms for the metropolis, solving no problems of men working in the vicinity of their home, and mitigating not one iota the curse, or should we say, the "blessing," of exploitation of speculative gain in terms of private home ownership.

Miss Bauer's most important point is made in Part 3, when she sums up post-war housing in the following words: "But all the Utopians, modern architects, and enterprising city fathers in Europe are not enough to explain either the quantity of post-war housing or the method by which it was constructed. If there had been no organized political demand on the part of the people who needed good housing, there would have been no such achievement. Housing was not bestowed from the top down in Europe any more than it ever will be in America. It had to be acquired by people who knew what they wanted and how to get it."

The "effectiveness" of this popular demand has resulted in making available four and a half million new dwellings to the lower-income groups of Europe. At a fair estimate of four and a half persons per dwelling, nearly twenty million persons, or about 16 per cent of the total combined populations of 132 millions of the British Isles, Scandinavia, and the Continent, have decent habitations. These state-aided dwellings amount to about 70 per cent of all new dwellings erected. Municipalities erected about 30 per cent of the four and a half million dwellings. Cooperatives erected 38 per cent and of the remaining, 32 per cent were put up by so-called private enterprise, under compulsory supervision of standards of layout and design and under rental regulations and restrictions as to resale. She ascribes the development of the housing movement in Europe to a fundamental premise that housing is a public utility. "The right to live in a decent dwelling has taken its place among the 'national minima'—the right to good and abundant water, to sanitation, to adequate fire and police protection, to the use of paved and lighted roads, and to education. . . ." The engineer will note how much involved his profession is in all these "minima." It therefore should not be too great a stretch of his imagination to understand why housing must be added eventually to the list.

ENGINEERING PROBLEMS

Part 4 of the volume "comes down to brass tacks" in so far as the engineer is concerned, as will be discerned from such chapter headings as "Minimum Standards in Practice," "The Community Unit," "Layout and Building Arrangement," "Building Types and Plans," "Construction," "Architecture," etc. Miss Bauer suggests to America a new housing norm defined by Lewis Mumford as follows: "The modern house is a biological institution. It is a shelter devoted primarily to the functions of reproduction, nutrition, and recreation. . . . Add to these primarily physiological requirements the provision of space for social companionship and play and study, and the definition of the house is complete." Once these elements are regarded as essential, an excess of luxury in one element does not make up for a lack in another. Pages 142–144 in Miss Bauer's book set out in comprehensive detail exactly these elements of decency, health, amenity, comfort, convenience, and safety. It is a startling statement that she makes that "not since 1919 would it have been legally possible to erect in Europe a typical New York tenement block or a Boston or Chicago frame three-decker. In other words, obvious "trimmings" are being added in the American low-rental group, but there remains a fundamental lack of adequate provision for light, air, noise, and fire prevention. Miss Bauer claims that less than 10,000 modern units have been erected in America since the War that are strictly comparable to the four and a half million European units. Still Europe looks to

us in matters of structural technology, central heating, air conditioning, uses of steel and concrete, and the like. An interesting chapter is devoted to a technical discussion of what constitutes this unit under varying conditions. Under the chapter, "Layout and Building Arrangement," the English and German super-block is discussed. Construction materials such as slag concrete cast on the site into standard forms, steel framing, preassembled units, vulcanized lava concrete, and such items are discussed together with costs of production, erection, and maintenance.

The next to the last chapter deals largely with land economics and site problems. In this connection Miss Bauer makes one of her challenging, clear-cut statements to the effect that "the enormous gap between an economic rent and the rent which people can pay is almost entirely due to the exorbitant cost of land. Most of the subsidy in such cases, therefore, is a direct grant in aid to the owners of slum property and should be honestly chalked up as such, and not as a cost of 'modern housing.'" The reader will sooner or later begin to wonder as to how the European municipalities got around this and other difficulties, and Miss Bauer is full of enlightenment. She explains that Berlin, for instance, for a generation has been making a frontal attack on the problem of inflated land prices. The city itself bought up raw agricultural land at about $2000 per acre, much of which is destined to be used directly for new housing, the rest for sewage, farms, municipal forests, and recreation places. It owns now one-third of its interior area of Berlin (about 78,000 acres) and 70,000 acres outside, which form a partial green belt surrounding the city and protecting it from speculative ribbon developments along the main highways. This policy of land acquisition over a period of years is also characteristic of Dutch, Scandinavian, and English municipalities. Other costs of financing, amortization provisions, maintenance, including repairs, insurance, and administration are given ample discussion.

The final chapter, "Modern Housing for America," is both a review of the past as well as a prophecy of the future. Few indeed are the examples in America that she can point to. However, she points out that architects and engineers are inclined to feel that housing, however dull by comparison with skyscrapers or Norman villas, is their one glimmer of hope in a drab future. She believes that the present chaotic policy toward housing in Washington is due to the variety of pressures brought to bear on the Administration. It is not beyond the realm of probability, therefore, that the Administration will compromise with a half-hearted program involving the demolition of a few of the more spectacular central slums and this provided not too much fuss is stirred up in the courts and provided no one's feelings are really hurt.

DENUNCIATION OF SUBSISTENCE HOMESTEADS ILL-CONSIDERED

The reviewer, however, takes decided exception to Miss Bauer's ill-considered denunciation of subsistence homesteads. A work connection is necessary for the homesteader to obtain the cash needed for living costs over and above the subsistence which his garden affords him. Furthermore, it is true that amortization, interest, and upkeep on the low-cost shelter must be met in cash. But to say this reduces the industrial workman to a new form of peonage is stretching things a bit and reflects an unmistakable prejudice that crops out here and there throughout the book. This prejudice is a refusal to see the probability of a continuation of "muddling through" which is characteristic of Anglo Saxon nations, a backing and filling, and a pragmatic meeting of emergencies as, when, and if they become threatening. Miss Bauer's emotional and undocumented denunciation of the German *Siedlungen* or homestead movement is decidedly the weakest spot in her book. She sees "politically" in such instances and fails to balance off an admittedly inadequate solution against what was intolerable or what would be Utopian perfection. The reviewer submits that the huge American relief rolls will be liquidated only partially by revived industry and every engineer knows full well the implications of technological unemployment, not only for the worker but for the engineer himself. One simply cannot escape the conclusion that a back-to-the-land movement is inevitable whether we like it or not, and whether or not it may place a large number of workers in a certain state of immobility of residence and work opportunity. The reviewer therefore recommends to the engineer his taking an interest in the federal rural resettlement program. It not only involves a certain amount of rehousing, but in the redistribution of population there will have to be established small industrial and agricultural cooperative undertakings in which the engineer should participate.

However, the engineer and the reviewer can agree with Miss Bauer's conclusion that "the touchstone of the post-war housing movement in Europe was the organized and well-informed demand: The German trade unions who were prepared to carry out a large-scale housing program with governmental aid on their own initiative, the townspeople of England who elected councilmen on a housing platform." Also, if we are open-minded we must further agree with her that "the lack of such a demand is the principal reason for all the obstacles which have piled up in the path of housing in America."

Effective Handling of Quality Complaints

(*Continued from page 637*)

WEEKLY QUALITY REVIEW

Every superintendent of manufacture should be informed of the quality performance of the product he has been instrumental in producing. To serve this purpose, a weekly review of the production and quality records is made with the manufacturing superintendents in attendance. Explanations are made of all reports reviewed for the benefit of those present. Many valuable suggestions have resulted from these gatherings and there has been established a spirit of understanding of the problems for which more than one superintendent may be responsible.

RESULTS AND CONCLUSION

The establishment and operation of the quality-control department have resulted in substantial savings and in improvement in quality throughout the entire plant. During the last four years, general quality figures indicate a reduction of imperfect product in excess of 50 per cent. The success of the plan in so far as plant operation and quality are concerned may well be determined not by how much profit was derived from its operation but by how much the losses and waste were reduced.

To operate successfully quality control must be invested with authority to curtail any operation throughout manufacture, providing the quality is such that it is uneconomically sound to continue. The duties of the superintendent of quality control may well be compared to those of the comptroller—one is custodian of quality and the other of policies and finances.

The value of quality control may be measured by the extent to which improvements are made. If the cost of control exceeds the loss resulting from inferior quality, all other factors being equal, then its existence is questionable.

CHIEF DELEGATES TO THE INTERNATIONAL ELECTROTECHNICAL COMMISSION MEETINGS

Standing (left to right): C. Le Maistre, Great Britain; L. Emanueli, Italy; E. J. F. Thierens, Holland; S. Norberg, Sweden; E. Patry, France; J. Havlicek, Czechoslovakia; F. Hodgkinson, United States; R. T. Smith, Great Britain; L. Kallir, Austria; and J. Burke, United States. *Sitting* (left to right): M. Chatelain, Russia; A. E. Kennelly, United States; L. Lombardi, Italy; C. H. Sharp, United States; C. Feldman, Holland; A. F. Enström, Sweden; E. Gevaert, Belgium; M. Kloss, Germany; C. D. Busila, Roumania; K. Drewnowski, Poland; A. Winter, Russia; F. Jacobsen, Norway; and K. Takahashi, Japan.

The 1935 MEETINGS *of the* I.E.C.

A PLENARY meeting of the International Electrotechnical Commission was held at Scheveningen from June 18 to 23, and at Brussels from June 24 to 29, 1935.

Twenty advisory-committee meetings were held during the two weeks, including those on steam turbines and internal-combustion engines. The committees which held sessions at Scheveningen were on nomenclature, aluminum, insulating oils, rules and regulations for overhead lines, radio communication, electrical installations on ships, electric cables, electronic devices, and steam turbines, while at Brussels meetings were held on symbols, lamp caps and holders, standard voltages and currents and high-voltage insulators, electric traction equipment, measuring instruments, terminal markings, switchgear, accumulator batteries, and internal-combustion engines.

The United States National Committee, I.E.C., holds the secretariats for nomenclature (advisory committee No. 1) steam turbines (No. 5) and internal-combustion engines (No. 19). The meetings of advisory committees Nos. 5 and 19 occupied all the available time in the week in which they were scheduled.

At both meetings a considerable degree of international agreement was attained, which was due, in part, to the fact that all the business coming before the committees had been the subject of correspondence between the various national committees and the secretariat.

The written opinions of the various national committees had been condensed in a number of written reports prepared by the secretariat which were submitted for discussion at the meetings.

The United States National Committee was represented by Francis Hodgkinson, acting director of the secretariat on steam turbines and director of that on internal-combustion engines, by K. McH. Irwin, delegate, and C. B. LePage, assistant director of both secretariats.

At the meeting of advisory committee No. 5 on steam turbines the several national committees were represented as follows: Belgium, Edgar Forgeur; Czechoslovakia, Milos Rubeska and Jaroslav Havliček; France, Georges Darrieus and Louis Cauchois; Germany, Emil Josse, Ernest A. Kraft, and Herbert Melan; Great Britain, Bedrich Pochobradsky (chairman), Frederick Samuelson, Henry L. Guy, John P. Chittenden, and Robert Dowson; Italy, Antonio Capetti; Sweden, Oscar A. Wiberg; Switzerland, Jean de Freudenreich; and the United States, Francis Hodgkinson and K. McH. Irwin.

I.E.C. publication No. 45, Part I, "Specification," and publication No. 46, Part II, "Rules for Acceptance Tests," had been finally approved in 1930 and published shortly thereafter under the six-months' rule. The business before advisory committee No. 5, therefore, was the consideration of amplifications to these publications and certain new proposals.

It had been agreed at a previous meeting that the rules contained in Section 4 of Part II, "Rules for Acceptance Tests," on instruments and methods of measurement, should cover only

the necessary mandatory rules, and it was so printed in publication No. 46, and that an appendix should be published containing non-mandatory rules and informative matter to be entitled, "Supplementary Notes to Part II, Section 4, Instruments and Methods of Measurement."

The proposals of the United States National Committee, I.E.C., for this appendix were briefly discussed at Stockholm in 1930, and, based on this discussion, the secretariat issued a new document, 5(Secretariat)20, to the various national committees in July, 1931. This was fully discussed and complete agreement was reached. Certain tabulations of physical quantities require corrections, the latest values for which are to be supplied in part by Emil Josse and in part by H. L. Guy. The secretariat is authorized on receipt of these data to prepare this appendix for submission to the I.E.C. Committee of Action to be issued under the six-months' rule.

MEASUREMENT OF FLUID FLOW

The French delegation pointed out at Stockholm in 1930 that committee No. 30 on the measurement of fluid flow of the International Standards Association had been charged with the responsibility of studying all the available work on flow measurement and making recommendations in the form of a standardized technique for international use. The French delegation proposed that the I.E.C. should bespeak the good offices of the I.S.A., requesting them to consider the data the I.E.C. had available and to recommend rules for the use of the I.E.C. advisory committees.

An I.S.A. document covering the technique of flow measurement, known as AFNOR—MD/Br—No. 3005, was circulated in May, 1935. This was discussed and agreed to as being suitable for the I.E.C. rules with two trivial modifications. It was agreed that the secretariat would await six months for the I.S.A. to confirm the proposed modifications and, in any event, at that time would print these rules in the supplementary notes and would submit the complete document to the I.E.C. Committee of Action for adoption.

A DEFINITION OF THERMAL EFFICIENCY OF STEAM TURBINES

A definition of the thermal efficiency of steam turbines was treated in a valuable technical paper by Georges Darrieus that was intended to provide a means of comparing the efficiency of steam turbines working under all kinds of operating conditions, with and without extraction. The French delegation submitted it in 1930, with the recommendation that it be considered for adoption by the I.E.C. At that time the matter was referred to the various national committees for consideration. After a full discussion at Scheveningen it was agreed that this definition of efficiency had no place in the rules for the testing of condensing steam turbines, but that it might have place in the rules covering extraction and similar turbines. Further discussion was postponed until these types of turbines are given consideration. However, rules for these latter types of turbines were later agreed to in principle, without the inclusion of this form of thermal efficiency. The subject "A Definition of Thermal Efficiency of Steam Turbines" may therefore be regarded as having been finally disposed of.

INCREASING THE SCOPE OF THE RULES

I.E.C. publications Nos. 45 and 46 embrace only condensing steam turbines with and without reheating, also, with and without extraction for the purposes of heating their own feedwater. It was proposed in 1930 that the rules should be amplified to include non-condensing and back-pressure turbines, also extraction and mixed-pressure turbines such as are used in the industries, as well as variable-pressure turbines such as are used in conjunction with heat accumulators.

At Scheveningen it was agreed that the rules should be made to include the following types of turbines:

(*e*) Non-condensing and back-pressure turbines.
(*f*) Condensing extraction turbines in which steam is extracted for purposes other than heating their own feedwater.
(*g*) Non-condensing extraction turbines.
(*h*) Mixed-pressure turbines which are supplied with steam at more than one initial pressure.
(*i*) Variable-pressure turbines which are supplied with steam at widely varying initial pressures.
(*j*) Turbines in which any of the above types are combined.

It was further agreed that the rules shall continue to require that no tests shall be undertaken except when all steam quantities requiring a quality determination to attain the object of the test are superheated.

It was further agreed that for the present an appendix to publications Nos. 45 and 46 should be prepared containing only the new matter made necessary by the inclusion of these types of turbines, with cross-references to relevant paragraphs in these publications. This appendix is to serve until a revision of I.E.C. publications Nos. 45 and 46 is required, when all the types of turbines embraced by the rules would be contained in one document.

A subcommittee was appointed by the chair to review the proposals which had been made by the various national committees and to report to the advisory committee its recommendations for the text of this appendix.

At the Friday session the subcommittee's report was accepted following discussion and modification by the members of the advisory committee. These rules will provide the following concerning turbines of types (*e*) to (*j*):

(1) The maximum permissible deviations of any of the test operating conditions from those specified except the pressure at the exhaust to the condenser shall not exceed ±5 per cent. The permissible deviation of pressure from that specified at the exhaust to the condenser shall not exceed +0.3 lb per sq in. or −0.1 lb per sq in.

(2) The steam quantity between any two points in the turbine where a deviation of any operating condition of ±5 per cent is not exceeded shall be corrected in the test for any deviation from the conditions specified inversely as the change of adiabatic heat drop between these points, it being assumed that the engine efficiency to that section of the turbine remains constant within the limits of permissible deviation.

(3) When the deviation of any test condition from that specified exceeds the permissible ±5 per cent, or the pressure at the exhaust to the condenser exceeds the permissible values specified in the foregoing, the corrections to be applied shall include not only that due to the adiabatic heat drop but also a correction for the change in leaving and exhaust losses. The values of both these corrections are preferably stated in the contract, failing which it shall be agreed to by the parties to the test before any tests are commenced.

(4) The average percentage difference between the corrected test performances and that guaranteed is to be determined by calculating the percentage difference between the corrected test result and that guaranteed for each guarantee point that the tests have verified. The average difference shall be the algebraic sum of the percentage differences at the various points, divided by the number of points.

(5) The steam rate is to be expressed by the total quantity of steam supplied under the specified condition divided by the output.

(6) The heat rate is expressed by the difference between the sum of the enthalpies of the steam supplied minus the sum of the enthalpies of water corresponding to the pressure at the respective outlets, divided by the output.

(7) Variable-pressure turbines type (*i*) are to be treated as mixed-pressure turbines type (*h*) or by special agreement between the parties to the test if the test is to determine the mean steam or heat consumption during the discharge of the heat accumulators.

It was agreed that the secretariat should prepare the new appendix and circulate it to the various national committees with the hope that the final agreement may be reached by correspondence, failing which the matter must stand over for a further meeting of the advisory committee.

INTERNAL-COMBUSTION ENGINES

The various national committees were represented as follows at the meeting of advisory committee No. 19 on Internal-Combustion Engines: Belgium, Edgar Forgeur and Albert Vandeghen; Czechoslovakia, Milos Rubeska; France, Louis Cauchois, Henri Monchelet, and Edward Patry; Great Britain, Oswald Wans, James M. Ferguson, and John P. Chittenden; Holland, Andreas B. Van Hamel; Italy, Antonio Capetti, Waldemar Mungioli, and Giovanni Chiesa; and the United States, Francis Hodgkinson and K. McH. Irwin.

The first meeting of this advisory committee was held in Stockholm in 1930, at which time various proposals were submitted but no agreement reached. Following considerable correspondence, the secretariat circulated 19(Secretariat)1, the proposed specification, and 19(Secretariat)2, the proposed rules for acceptance tests, in anticipation of an advisory committee meeting to take place in New York in September, 1933, the plans for which were abandoned as also were those for a meeting in September, 1934.

Between the time of printing 19(Secretariat)1 and 19(Secretariat)2, and the meeting in Brussels in 1935, there had been a sufficient number of written opinions to warrant a reprinting of these two documents in revised forms. These were circulated to the national committees as 19(Secretariat)3 and 19(Secretariat)4 and formed the basis of discussion at Brussels.

Definite agreements were reached concerning 19(Secretariat)3, "specification," which, with certain minor modifications, will be submitted by the secretariat to the I.E.C. committee of action for issuance under the six-months' rule. An early copy of this draft is to be sent to the French National Committee, I.E.C., for translation into French.

Proposed "Rules for Acceptance Tests," 19(Secretariat)4, was discussed and the proposal of the United States National Committee for shortening section 4 (instruments and methods of Measurement) to only the necessary mandatory rules for measurement, and relegating the non-mandatory rules and informative matter to a document called "Supplementary Notes to Part II, Section 4," was accepted. This procedure is the same as had been agreed to in the development of the rules for acceptance tests of steam turbines.

The secretariat was authorized to prepare a new document covering Part II, "Rules for Acceptance Tests," which will be circulated to the several national committees for acceptance. However, should differences of opinion arise which cannot be composed by correspondence this material must be held over for further meetings of advisory committee No. 19.

Both meetings concluded with a vote of appreciation and thanks to the secretariat for its labors.—FRANCIS HODGKINSON.

Young and Phelps

A VISTA OF MACHINE TOOLS—PORTION OF 1935 MACHINE TOOL SHOW WITH AN EXHIBIT OF MONARCH LATHES IN THE FOREGROUND

CONTROL—PRECISION—PRODUCTION

Outstanding Developments Seen at the Machine Tool Show, Cleveland, September 11–21

CONTROL, precision, production: These were the three outstanding impressions which one observer, at least, received at the 1935 Machine Tool Show.

It is impossible to give a complete description of the Show. Exhibitors ran to about 250; and every exhibitor was displaying, and eager to talk about, the developments over which he and his engineering and designing staff had been working during the long—but not unfruitful—years of the depression. More than that, in the two and one-half days that the present observer had allowed for his inspection he was unable even to *see* all the exhibits, let alone inform himself on their many new and interesting features. Tramping over five and one-half acres of exhibition space in the Cleveland Public Auditorium, all occupied with exhibits, is no easy task.

The 1935 Machine Tool Show, which opened in Cleveland on September 11 and closed on September 21, is the first held since 1929. The National Machine Tool Builders' Association, sponsors of the show, displayed a high quality of leadership and showmanship in this enormous and spectacular venture. Orderliness, good management, and good housekeeping were evident. When the doors opened for the preview on Tuesday at 2 p.m., everything was ready. The usual last-minute bustle of late arriving exhibitors, the confusion and pounding during final preparations, and the gaping emptiness of vacant stalls were mercifully absent. In their place was a scene of well-organized, beautifully arranged exhibits, every machine painted the same color—machine tool gray—and every exhibit giving evidence of painstaking care in preparation.

To one whose memory of machine-tool shows ran back to the modest beginnings in the early twenties the contrast was staggering. For it must be admitted that the present show had its inception in the exhibits held annually at New Haven under the auspices of the A.S.M.E. and Yale University. An educational purpose was back of these first shows, as the exhibits were assembled in connection with a summer course in the mechanical engineering department of the Sheffield Scientific School. And educational the shows remained after they were given up at New Haven and sponsored by the National Machine Tool Builders' Association. Educational to a highly convincing degree was the 1935 show; and if the appeal has changed from an academic to an industrial audience, let it be said that teachers of machine design and other mechanical engineering subjects, and their students, could have learned more by visiting this show than by many times the hours spent in classrooms, and engineers in industry who missed it lost an opportunity of finding out in a very simple way what has been going on in several hundred drafting rooms, experimental laboratories, and shops while business conditions have been

GOOD SHOWMANSHIP—GREAT CONVENTION HALL HOUSING A SMALL PORTION OF THE 1935 MACHINE TOOL SHOW—ACROSS STAGE AT REAR ARE SOME MACHINE TOOLS OF FORMER GENERATIONS—NOTE GIGANTIC PHOTOGRAPHS OF MACHINE TOOLS THAT FLANK SIDES

too slack to demand the full time of expert staffs in maintaining routine production.

RETURN OF CONFIDENCE NOTED

The keynote of the show was the return of confidence and prosperity to the machine tool industry, and its chief claim to importance lay in the high percentage of new developments that were displayed.

As to the first point. Statistics have proved that the industry has its ups and downs and that these fluctuations are of a "barometric" character in so far as industrial-production "weather" is concerned. Among others, W. H. Rastall, formerly chief of the Machinery Division, Department of Commerce, in a chart presented in the January, 1933, issue of MECHANICAL ENGINEERING, clearly showed that this is so. On this chart, machine-tool orders since 1919 were plotted in comparison with the industrial-production curves of the nation. The curves show the rapid fluctuation of machine tool orders from precipitous peaks to almost sea-level valleys. And a comparison of the two curves shows that trends in the machine-tool curve precede tendencies in the industrial-production curve by several months. A rise in machine tool orders has, in the past, been prophetic of increasing industrial production. Such has been the history of the industry.

Today the optimistic—and there was plenty of optimism at Cleveland—are saying that history is going to repeat itself. The machine-tool index has been climbing steadily for some months, and on the day the show opened it had reached 120 from an almost unbelievable low. Many shops can make no deliveries for months. Shop orders, placed with some daring and hesitation, are being rapidly stepped up as general industry responds to the opportunity to cut costs and replace obsolete machinery in the face of returning confidence. Some shops are working more than one shift. Most are finding it difficult to employ enough skilled mechanics.

To a machine-tool builder the technical designing organization is vitally necessary. Competition is keen and developments are rapid and sometimes revolutionary. Reciprocal urges from production industry to the machine-tool industry and vice versa maintain a rapid flow of ideas and innovations which must be put into new designs if the manufacturer is to stay in business. Unwilling to let the backbone of their staffs go, even with little or no business, machine-tool builders have kept them steadily at work on an astounding variety of developments, the first of which were on display at Cleveland.

Those who had a feeling that they knew pretty well what the industry was doing were almost as amazed as those whose interests had separated them from day by day contact. Basically the same tools that the manufacturing industry has relied upon for generations, the machines themselves have undergone refinement and development to a degree all the more marked because of the six-year lapse since the last show and the unusual activity of builders preparing for a returning prosperity.

IMPROVED CONTROL FEATURED

As pointed out at the beginning, control, precision, and increased production are outstanding features.

Electrical and hydraulic devices are responsible for most of the improvements in control, although pneumatic and mechanical devices have not been overlooked in ingenious attempts to increase the ease with which the machine may be operated and to substitute automatic for manual methods.

Two machines, almost human, to use a trite but inescapable expression, illustrate the hydraulic and electrical methods. Both are used in diemaking and reproduce from a master model—one actuated by oil under pressure, the other by electrical circuits. With baffling intelligence and unerring precision the finger tracing around the surface of the model communicates to an identically moving cutter its ever-changing motions. Somewhere in the hydraulic or electrical nervous system of the machine instantaneous responses to the "feeling" action of the finger are communicated to the cutter.

Another manufacturer, applying the principle to lathes, is able to turn automatically any variety of contour, internally and externally, in radial or axial directions. Switchboards, motors, electrically operated clutches, relays, contacts, wiring, of course are at the heart of this old gunstock turning lathe gone scientific and ultra modern.

Electrically operated chucks were also in evidence as well as those controlled by oil and air pressure. One manufacturer of a multiple-spindle automatic chucking machine has mounted a motor on every spindle so that in the loading position, through electrical contacts they are energized and operates the clutch.

Push-button control is no new development, but extensive use of it has enabled the operator to start, stop, reverse, and "inch" his machine from whatever position attention to his work demands his presence.

A system of electrical circuits is used by one manufacturer to synchronize the operations of numerous work heads, all per-

forming automatically on different parts of the work piece held on an indexing table. Except through their supports there are no mechanical connections between these work heads, and yet the operations are perfectly synchronized.

Speed-changing devices demand especial attention. Of gearing of all kinds there is, of course, ample evidence, but the ease with which speeds are changed, whether by hand, by electrical, or by hydraulic devices, is especially marked, and the tremendous number and wide range of speeds for drives and feeds is impressive. Lathe spindles are electrified in some cases, a multiple-speed motor being mounted directly on the spindle. Others use hydraulic drive, and still others showed applications of a brand new speed-changing device which provides continuous range from lowest to highest with the turning of a small crank on which the actual spindle speed is indicated. Preselection of gears for the next step of a series looks like an adaptation of automobile transmission devices occasionally featured. During one cutting operation the operator turns a cylinder to the number corresponding to the next in the sequence, and when the operation in process is completed, shifts his gears to the speed for the next by a movement of a single lever. All he has to remember is that four comes after three.

LOOKING ACROSS THE BOOTH OF THE EASTERN MACHINE SCREW CORPORATION INTO ANOTHER PORTION OF THE 1935 MACHINE TOOL SHOW

One very noticeable feature was the extensive use of hydraulic drives and controls. Wherever straight-line motions are involved, as in feeds, for example, the application is obvious. But the simplicity, ease, and smoothness of operation command admiration. And applications of hydraulics to almost every element of drive, feed, and control were innumerable. New and better pumps were shown, beautifully made and extremely ingenious as mechanisms—gear pumps, piston pumps, wobble-plates, rotary pumps—almost every conceivable kind of device for this purpose. The pumps themselves and the machines to which they were adapted have been characterized by many manufacturers by some trade name in which the syllable "hyd" has obvious distinguishing significance.

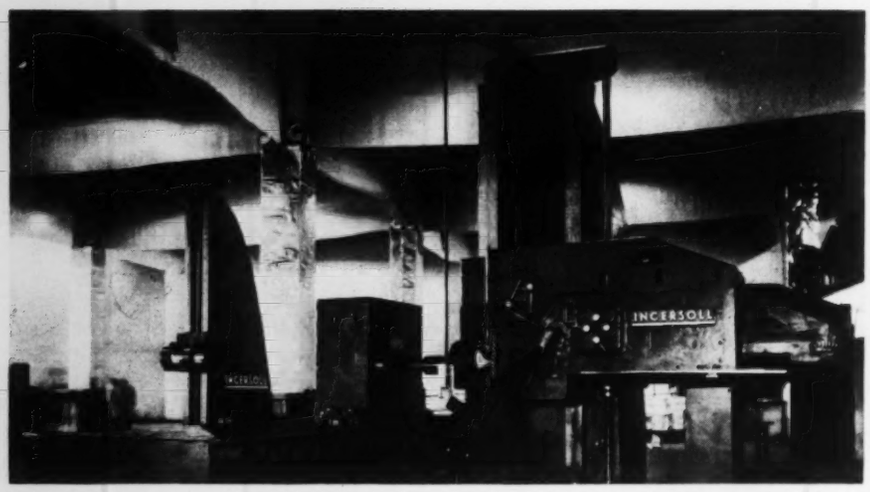
Broaching is coming into its own, and to the broaching machine the hydraulic drive is particularly adaptable. One recalls the broaching of holes and keyways, an infrequent and almost obsolete process a few years ago, carried on in a screw-driven machine that moved the broach fairly slowly. Now we have changed all that. The shaving cut of the broach leaves a smooth surface, almost polished in appearance. The operation is quickly done, and external surfaces as well as holes of all shapes and sizes are being broached at amazing speeds. For certain types of work that are rapidly being discovered, the broach is apparently taking over the field of form milling.

GREAT PROGRESS IN PRECISION

But if developments in control excited admiration and comment, precision in manufacturing to close tolerances and superior finishes on metal surfaces did also. Here honing, lapping, and grinding were in evidence, and the rapid progress in these arts was remarkably demonstrated. What was formerly a toolroom or laboratory finish is becoming a commonplace, necessitated by the demands of quality in mass-production industries. Diamond bored and turned surfaces come from these machines as though they had been plated. Lapped surfaces, in centerless machines on cylindrical pieces, show, under the microscope, no scratches of tool or grit. Cylinders and cylinder liners go into engines with the polish formerly acquired by long wear under careful operation.

The variety of devices for grinding seemed almost limitless, and the applications amazing. Flat and round surfaces have long been fields for this kind of finish, but the problem of irregular surfaces, such as gear teeth, for example, call for complicated and ingenious mechanisms that were amply demonstrated in great variety. Cutter and drill grinders can be had in great numbers for an infinite variety of small tools. Manufacturers of milling cutters, die chasers, and other varieties of cutting tools, as well as manufacturers of grinding equipment, have been forced to develop machines for grinding accurately the cutting edges of modern tools, as experience has shown them that most complaints originate in improper grinding. In this connection it was noted that one manufacturer of collapsible die heads and taps has adopted the razor-blade idea in his salesmanship. He supplies inserts for his chasers, weighing only a small fraction of standard cutters, that are so inexpensive that they may be thrown aside when dull. Yet there is sufficient stock for several grindings if the user wishes to get the maximum out of the metal.

Progress in mass production has depended, since the days when Colt began using standard gages, on precision of measuring devices as well as accuracy of manufacturing operations. Every mechanical development—the gear, the thread, the bicycle, typewriter, telephone, radio, automobile, airplane engine—as it has come along has found it necessary to demand greater precision; and hand in hand with this demand have come the devices by which accurate measurements are made, and manufactured articles gaged and compared to standards. Vernier calipers and the micrometer were steps in developing



EASY CONTROL OF LARGEST MACHINE TOOL IN THE SHOW—AN INGERSOLL MILLING, BORING, THREADING, TAPPING MACHINE. NOTE PUSH-BUTTON CONTROL IN OPERATOR'S LEFT HAND

shop instruments. Snap and limit gages provided more accurate measures. But the ingenuity of gage manufacturers and designers has not stopped there, and the arts and crafts of the shop, which relied so largely on experience, have been amply supplemented, and in some cases supplanted, by easily operated and highly scientific instruments.

One interesting development that means so much to economy in precision manufacture is the great number of precision instruments for gaging, inspection, and comparison to standards that are no longer toolroom and laboratory instruments but practical easily operated inspection devices used at the bench, the machine, or the assembly line, providing a ready check on work in process from which correcting influences can be initiated before too much waste has developed. At the show were displayed many such devices which excited admiration on account of the ingenuity and effectiveness of their designs and functions and the quality and beauty of their workmanship. Practical devices, as has been said, they bring a high degree of precision to bear at the very operation, instead of serving merely in post mortems. Gear teeth and thread profiles and characteristics are compared and measured in a variety of ways by a variety of machines. The dial indicator, so long familiar at inspection tables and on machines, is being augmented by electric gages of extreme sensitivity, rugged and foolproof construction, and easy operation. Great adaptability of this type of gage was amply demonstrated.

The laborious process of laying out work with the surface place, V-blocks, squares, scribers, gages, and other fundamental measuring devices bids fair to disappear in much jig work. Jig-making machinery was displayed in which accurate spacing is accomplished without layout, the machine itself incorporating the precision devices that make layout unnecessary. In fact, it was said that jigs made on these machines are sent to the shop without checking, as the gage blocks used in them to determine movements of the jig with respect to the tool are of the same accuracy as would be used in the checking.

PRODUCTION HAS BEEN INCREASED

Time and space are important factors in low-cost production; and on low-cost production the life of modern industry depends. Demonstrators exuded excitement and enthusiasm in talking about cutting seconds off production time, about speed and feed changes that might increase production and hence lower cost, about designs that saved floor space, about machines that stood on their ends where they used to lie flat, and motors that were placed at angles or vertically so they would not overhang and add to floor space required. Speeds have been stepped up. Tungsten carbide and other metal-removing tools of high capacity were in increased evidence, as were sturdier frames and tool holders, broader ways, steel ways replacing cast iron, aluminum rams for high-speed shapers to cut down inertia. Motors are bigger to give the capacity needed for high production. Hydraulic and electrical speed-changing devices, already mentioned, are ingeniously arranged for rapid traverse in reverse and during non-cutting periods of the cycle. A planer that cuts on both strokes was shown—here the capacity must be nearly doubled. Mechanical ambidexterity was demonstrated in machines that were provided with multiple tools, many working simultaneously on every available surface of the piece.

An eight-spindle automatic was displayed; and on another, an automatic stock-changing device cuts down lost time in this operation. Antifriction bearings, an accompaniment to high speed, were almost universal. Lubrication is at last being treated less like a stepchild. Forced-feed and enclosed splash systems with pumps, sumps, strainers, and coolers, adapted from automobile practice, were in evidence. One demonstrator told how much less was the expansion in the machine due to cooling the oil 35 degrees. It was not uncommon to see a long battery of sight-feed lubricators mounted on a machine. A scraper conveyor for ridding the machine of chips was a feature of one display, while many others might have been similarly provided to lessen the labor and annoyance of raking and shovelling great spirals of cuttings from high-production machines, although a number of long-hole drilling operations were noted in which reversal and withdrawal of the drill at intervals freed the hole and prevented clogging of the drill.

It was a great show!

VETERAN MACHINE-TOOL BUILDER, AMBROSE SWASEY, HON. A.S.M.E., AND COL. E. A. DEEDS, MEM. A.S.M.E., INSPECT MODEL OF MCDONALD OBSERVATORY, BUILT LIKE A TURRET LATHE, FOCAL POINT OF WARNER & SWASEY AND PRATT & WHITNEY EXHIBITS

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

One-Pound-per-Horsepower Engine

THE Bristol Aeroplane Company has disclosed the results of tests on a Pegasus X engine. Weights below one pound per horsepower have previously been attained in racing engines. For instance, some of the engines fitted in the Schneider seaplanes weighed about three-quarters of a pound per horsepower. The first batch of these engines is in hand for delivery in the autumn, intended for "prototype" aircraft, and real production in quantities will be in operation by next spring.

Although the normal power of 820 hp at normal speed is in itself remarkable enough for an engine weighing but 995 lb, the remarkable take-off power of 920 hp is really the outstanding achievement. It has not been obtained by speeding up the engine, which runs at the relatively low speed of 2250 rpm at the take-off power, but by increasing the boost pressure. This again, apart from detail improvements in the engine itself, has been made possible by the introduction of 87-octane fuels. As it seems likely that in time fuels of even higher octane values may be sanctioned, one may expect some startling improvements in aircraft-engine and aircraft performance during the next year or so. (*Flight*, vol. 227, no. 1376, May 9, 1935, p. 493)

Mignet Airplane

AN interesting light airplane is just becoming known outside its home in France. Three unusual factors are of interest in connection with it. The designer is neither an engineer nor an airplane designer, and is not a pilot, yet the machine is cheap to construct and it apparently flies successfully.

Henri Mignet, the constructor, started by building gliders, and built eight machines in all before his final success. The unique construction of the latest will be quickly realized when it is stated that it has no ailerons it has a rudder, but no normal tail fin. Lift is obtained with two main wings, but not arranged as in a biplane, as the lower wing is situated just behind, but not quite clear of, the top plane and with not so much vertical distance as is normally the case between the planes of a biplane. Control is secured by altering the angle of incidence of the top plane, this being hinged and readily operated by the control lever. As the latter is linked with the rudder the little machine is enabled to make a stable right-hand or left-hand bank. This fact alone cuts out one element of danger to the beginner, as it enables a turn to be made by the use of the joystick only. A 17-hp engine is used, and this gives a speed range of from 25 to 62 mph. Costs are difficult to arrive at, as the machine is "home" constructed, but the inventor claims the costs are considerably less than the "Air League," who have gone into the matter in England. He estimates the cost to be about 90£, 65£ of this being the cost of the French two-cylinder engine.

The position occupied by the engine is interesting. This is hung beneath the top plane, but rather toward the front, while the pilot sits immediately behind it. Performance can be best realized from a summary from *Les Ailes* of Dec. 13, 1934, describing a test flight. "Heavy clouds passed over the hangars on this December day. At times the rain fell in torrents. The official figures gave the wind at 20 mph, with gusts up to 40 mph. The pilot (the constructor, M. Mignet) was uncertificated, the machine unlicensed and homemade. With disconcerting ease the 'Flying Flea' took off after a run of a few yards. It climbed quickly, giving the unexpected impression of a machine of greater power. Mignet made great use of his 15 min and showed off his 'Flying Flea' in a complete and instructive manner. Turns, dives, up wind and down wind, hedge hopping at high speed, high flying, a landing with a few yards of run, restart and landing with 'dead stick' (i.e., no engine)." (*Engineering*, vol. 139, no. 3616, May 3, 1935, p. 465)

Power for the "Pou"

THE "Pou-du-Ciel" or sky louse airplane is apparently attracting a good deal of serious attention abroad. A special engine of 17-hp output has been developed for it by Aubier and Dunne. It is of two-stroke cycle inverted type with two air-cooled cylinders cast *en bloc* in aluminum alloy and provided with steel liners. The cylinder heads, also of alloy, are separate and each is secured by four studs. The cylinders have a bore of 70 mm and a stroke of 70 mm and 17 hp is developed at 4000 rpm delivering 1600 rpm to the airscrew shaft through a reduction gear.

At the rear end of the crankshaft is a special flywheel magneto with windings which give independent ignition for each cylinder, and at the forward end is a duplex plunger-type oil pump, with sight feed, furnishing an oil supply direct to each cylinder wall. Actually this is an auxiliary supply, since the main lubrication method is by oil mixed with the fuel in the ratio of 6 to 7 per cent.

It was at first assumed that the wing arrangement used by Mignet in his "Pou-du-Ciel" is likely to be somewhat inefficient, but Maurice Victor (*Les Ailes*, Apr. 4, 1935) states that tests carried out at the laboratory at St. Cyr on somewhat similar wing arrangements have shown the arrangement to be very efficient, the drag being lower, the lift greater, and the L/D ratio greater than the corresponding figures for a monoplane wing.

On the other hand, W. E. Gray, who made small-scale tests on model wings, comes to the conclusion that in so far as spinning characteristics are concerned the "Pou-du-Ciel" does not differ from the conventional machine.

From these results it seems that the pilot will have to be very careful with the rudder, but the movement of the stick is at least instinctive and not reversed as with most aileron controls. With the center of gravity at 0.3 it seems necessary to reverse the rudder to end a turn, but with center of gravity at 0.5 it need only be centralized. Tests with half the dihedral showed a somewhat reduced tendency to enter a spin, and the spins had much more outward sideslip. The longitudinal and directional stability in gliding flight was marked

in all cases. It should perhaps be added that although the wide spin in free air becomes tighter with increased rudder, there seems to be no transition back again in any of the tunnel cases except one. (*Flight*, vol. 27, no. 1372, Apr. 11, 1935, pp. 385–386, 4 figs.)

The Lanier "Vacuplane"

IN A conventional airplane the air flows over the cell and creates a downwash. In the Lanier "vacuplane" the air flows over the nose, or entering edge, in the conventional manner, but instead of going down, flows up before and after leaving the trailing edge of the cell.

In tests made by a number of pilots it was found that the vacuplane does not slip or dive in a stall. This is due to the quick evacuation of the concave cell and the distribution of the lift forces, even at low speeds. The concave cell acts as an inverted parachute and when the ship settles, the plane is self-balancing, and, if desired, the pilot can still maintain longitudinal and lateral control.

Take-off and climb were found to be satisfactory. The ship is stable in flight, maintaining a normal flight attitude with hands and feet of the pilot off the controls. One of its characteristics is its inherent lateral stability in all flight attitudes.

In landing, the vacuplane indicates the desirable tendency of adhering to a steep descent, while control is maintained with little forward speed. Upon landing the plane can be brought to a stop within a short distance, allowing landings in restricted and small areas. (Edward M. Lanier in *Aero Digest*, section of *Aviation Engineering*, vol. 26, no. 2, February, 1935, p. 46, 1 fig.)

The "Varivol"

IN THE "varivol" now being built by Jacques Gérin, in France, an attempt is made to produce a machine with a variable wing area. Most of the fixed wing of the orthodox airplane is only necessary for take-off and to give aerodynamic braking for landing. When the machine is in the air the extra surface is only an unnecessary drag. The use of narrow wings on the other hand permits heavy loadings and a reduction of torsional loads with a consequent elimination of the possibility of sudden increase in load due to the change of incidence of an insufficiently steep wing.

The wings of the varivol have three essential peculiarities. The surface can be reduced from 302 sq ft to 72 sq ft, a ratio of 4.12. The camber of the extended wings can be varied. There are four slots in each lower wing and three in the top. The extensible part of each wing can be rolled up inside the fuselage, or wound along the leading and trailing edges of the fixed portion. The fixed portions of the wing are arranged as a biplane.

The upper wings have a sweepback of 13 deg. The lower wings have a dihedral of 5.5 deg. The fixed portions are made of duralumin. The main members are a pair of tubes of duralumin held close together. The moving parts of the wings are made of spruce, plywood, and duralumin, and are hinged at two points along the chord. Apparently their attitude is controlled by movements of the center of pressure.

The flexible portion of the wing is covered with a special rubberized fabric. The leading edge of each movable portion is composed of an ingenious structure which can be rolled up, but after unrolling is rigid in compression or bending.

The structure consists essentially of two ribbons of spring steel hinged on the whole of their length. Obviously, when the two portions of the hinges are in the same plane, the whole thing can be coiled up, provided the hinge-pin is flexible. When the two portions of the hinge are inclined to each other at a right angle or less, the structure at once becomes rigid.

The wings are wound in and out by an electric motor. Each wing can be rolled in or out independently of the other. The fuselage is built of chrome-molybdenum-steel tubing welded together. The forward portion is covered with duralumin sheeting. The rest is fabric.

The author of the article states that the varivol seems to be based on sounder ideas than are at first apparent from its peculiar appearance and may reasonably be expected to work, always provided that the wings do not jam in or halfway out. (*The Aeroplane*, vol. 48, no. 1247, Apr. 17, 1935, pp. 444–445, illustrated)

CORROSION

Third Report of the Corrosion Committee

THIS Committee is a joint committee of the Iron and Steel Institute and the British Iron and Steel Federation and is part of the Iron and Steel Industrial Research Council. The third report was presented at the annual meeting of the Iron and Steel Institute on May 1, 1935, and is an extensive document. The Committee's work is now in full swing, its atmospheric corrosion tests covering corrosion of mild structural steel, of both ordinary and copper-bearing varieties, ingot iron, and various wrought irons. Further specimens of high-tensile structural steel, chiefly of the copper-chromium type, have been prepared and the Committee has now 14 corrosion stations scattered all over the world. It has been already found that in the case of material rolled according to the normal works practice, the rolling scales of British wrought iron and on ingot iron are more resistant to weathering than those of mild steel. The presence of copper in mild steel and Swedish iron was found to reduce the rate of corrosion considerably; in the case of steel, however, no difference was found between specimens containing 0.2 per cent and 0.5 per cent of copper, respectively.

Some time ago the Committee undertook with collaboration of the Great Western Railway Co. a series of tests on the corrosion of steel railway ties under service conditions. Both ordinary and copper-bearing steel have been used and an inspection made after a service of about $2\frac{1}{2}$ years. It was concluded that there is a definite difference in the conditions of service according to whether the tie is in the vicinity of a rail joint or in the middle of a rail length, and there is a possibility that there is a difference between leading and trailing ties, that is, ties that are at the front and rear ends of the rails with respect to oncoming trains.

The report deals also with steel plates built into a barge and subjected to various bends and sand blasting and various laboratory tests. (*Engineering*, vol. 139, no. 3616, May 3, 1935, p. 460)

ENGINEERING MATERIALS

Tungum Alloy

TUNGUM alloy is a material developed in England. It is claimed that it is non-corrosive in the presence of sea water and that whereas naval brass shows a tendency to continue wasting, the wastage of tungum metal decreases with time, reaching a maximum about three months after initial immunization, and giving a figure of 0.000551 grams per sq cm. Data of mechanical tests carried out by Dr. Laws at the University of Sheffield are given in the July 12 issue of *The Engineer*.

The rate of percentage composition of the alloy is contained in a recent Air Ministry specification for tungum tubes. This gives copper 81 to 84 per cent;

aluminum 0.75 to 1.20; nickel 0.85 to 1.40; silicon 0.80 to 1.30; and zinc the remainder. The alloy is said to be replacing copper and other metals in tubes and pipes in aero engines. The material is of unusual ductility and it is said that the piece of tube has been cold drawn from 1 5/8 in. diameter no. 19 gage (0.04 in.) down to a thickness of 0.004 in. (*Engineering*, vol. 140, no. 3625, July 5, 1935, p. 9, and *The Engineer*, vol. 160, no. 4148, July 12, 1935, p. 44. The two articles are complementary to each other.)

Silver-Soldered Stainless Steel

DATA on a series of butt joints of cold-rolled 18–8 stainless steel made with a 50 per cent silver solder in a research laboratory. It was found that the width of the joint should be less than 0.005 in. and preferably between 0.001 and 0.002 in. With joints thinner than 0.001 in. it is difficult to obtain a continuous film of solder free from bare spots, whereas if the solder is thicker than 0.005 in. the strength rapidly decreases and approaches that of the cast solder. The tensile strength of the steel used was about 160,000 lb per sq in. before soldering. The strength of the solder in the cast form which is the condition of the solder in the joint is approximately 50,000 lb per sq in. Yet joints have been made having a tensile strength as high as 134,000 lb per sq in. or nearly three times as strong as the solder. Although a number of contributing factors may partly account for this, no completely satisfactory explanation of this phenomenon is said to have been offered. (*Mining and Metallurgy*, vol. 16, no. 345, September, 1935, pp. 392)

Beryllium-Copper and Beryllium-Copper-Cobalt Alloys

TO meet the high price of beryllium-copper alloys an attempt was made to reduce the percentage of beryllium present. It was found, however, that this produced a sharp drop in strength and hardness of the alloy.

A study of the equilibrium diagram of beryllium and copper revealed that the copper alloys were of the precipitation-hardening type. That is, the copper is hardened by the critical dispersion of the beryllium-copper compound, by precipitation, through its matrix. This precipitation is brought about by first supersaturating the copper with beryllium—2.5 per cent beryllium is quite ample for this—and then controlling the precipitation of the beryllium by proper heat treatment. Any third metal which would serve to make beryllium less soluble in copper would lower the amount of beryllium necessary to force precipitation. A small percentage of cobalt was so effective in lowering the solubility that only about 0.1 per cent beryllium remained in solution at room temperature. Since only a small amount of beryllium is required to produce the requisite hardening effect, alloys containing varying small amounts of beryllium plus an addition of cobalt had qualities similar to those of the more expensive alloys with 2.5 per cent of beryllium.

Among the advantages of the addition of cobalt is mentioned increase of electrical conductivity and raising of the precipitation-hardening temperature of the alloy from 275 C to about 500 C. Moreover, the cobalt alloy remains stable at much higher temperature than an alloy without cobalt. The alloy may be produced in any form in which brass is produced. Some of the uses of this alloy are indicated. (F. G. Benford in *General Electric Review*, vol. 38, no. 6, June, 1935, pp. 297–299, illustrated)

K-Monel Metal

K MONEL metal is produced by the addition of a small amount of aluminum to monel metal. The interesting feature of this alloy is that it may be softened or hardened by heat treatment. It contains nickel of the order of 63 per cent, copper 30 to 31 per cent, aluminum 3.45 per cent, and the rest iron, manganese, carbon, silicon, and sulphur. This composition retains the corrosion-resistance characteristic of monel metal with the added advantage of increased strength after heat treatment.

The alloy in its hardest grade has a proportional limit in excess of 100,000 lb per sq in., a tensile strength in excess of 160,000 lb per sq in. with elongation (in 2 in.) of more than 15 per cent, combined with the corrosion resistance of monel metal. Tempered to lower hardness, the ductility is greater and the strength less.

K monel may be softened (annealed) by heating to a temperature between 1400 and 1500 F, preferably 1450 F, for a sufficient time to insure heating throughout, followed by quenching in a suitable medium, such as water or oil. Quenching is essential; the alloy is not soft on air cooling unless the cross-section is small. Open heating in a sulphur-free reducing atmosphere is preferred to using a box because of the greater ease of quenching. Water is most commonly used as the quenching medium, and it is good practice to add 1 to 2 per cent of denatured alcohol to the water quench. The alcohol reduces the film of oxide on the metal and results in a much more rapid and uniform pickle.

Maximum hardness due to heat treatment alone, starting with soft metal, is in the neighborhood of 300 Brinell, but if the hardness of soft material is raised by cold working, then the hardness resulting from subsequent heat treatment will be superimposed. Thus, in cold-worked metal a hardness of approximately 250 Brinell can be increased by heat treatment to 350 to 400 Brinell.

It has been observed, however, that if the K alloy, hardened by cold work plus heat treatment, be exposed to heat-treating temperatures (about 1100 F) for long periods of time, the hardness due to cold work will be eliminated and the Brinell values will fall to approximately 300; that is, the value obtainable by heat treatment alone.

Maximum hardening is accomplished by slowly cooling from 1075 to 1100 F. The use of higher temperatures results in lower hardness. The hardness increases with increased time of holding at temperature up to 6 to 8 hr and little is gained by holding longer than 8 hr.

This new alloy can be machined quite readily and at practical production rates in hardness grades *A*, *B*, and *C*. It can also be machined at slow speeds with especially hard tools, e.g., carboloy in hardness grade *D*, but this is not recommended and can usually be avoided by machining before final heat treatment. Like any alloy having properties different from those a machine shop is used to machining, this alloy requires tool angles, speeds, and feeds specially chosen to give best results. Sufficient experience has been had in its machining so that procedure can be outlined which will allow the average shop to handle it at outputs, ranging with the type of operation, from half that on machinery steel to nearly the same. (Technical bulletin to be issued by the International Nickel Company, signed by C. A. Crawford and G. F. Geiger, abstracted through *Metals and Alloys*, vol. 6, no. 4, April, 1935, pp. 101–105, illustrated)

FOUNDRY

Sand Wizard Shot-Blast Cleaning Machine

THE fundamental difference between the Wizard (machine developed in England) and the ordinary sand or shot-blast outfit is that a jet of sand is pro-

jected by centrifugal force instead of by compressed air. It is claimed that the new machine is very economical in power consumption. In the machine described a 9-hp motor has been installed and it is claimed that only 5.4 hp is being used. A compressed-air machine of equal capacity requires a 35-hp motor. The nozzles, made of special alloy steel, last about 30 hr. (*Foundry Trade Journal*, vol. 53, no. 988, July 25, 1935, p. 64, 2 figs.)

A New Multi-Casting Process

WITH the ordinary multi-casting process the plates which carry the top and bottom pattern half are forced into the sand of the molding box and the superposed flasks are cast through a common runner. This system has, however, some disadvantages. As a large number of flasks are placed one upon the other they should be broad and shallow and not deep, hence the multi-casting process can be adopted in the main only when molding shallow and small castings, such as kitchen-range rings, and gas-pipe fittings. Besides, as there is only one runner, the castings are joined to each other and in the process of separating the castings and runner trouble often arises. The main reason for limiting the application of the multi-casting process, however, is that it can be adopted only in connection with a certain number of light and rather thin-walled castings, as otherwise if the ferrostatic pressure is too high, the bottom molds may lift and the dimensions of the castings exceed the specified tolerance.

It is said that the Badische Maschinenfabrik of Durlach has now succeeded in eliminating these disadvantages. The flasks are as usual placed one upon the other, but they are cast separately, the runners being located alternately on the right and left of the narrow side of the assembly and passing through the flask down to the runner of the flask below. To have sufficient space for the lips of the ladles the boxes are provided with lateral openings, shaped as a quarter circle on the corner opposite to the runner, leaving the runner of the next flask open at that point. By this provision each flask can be cast separately and lifting due to too high a ferrostatic pressure is eliminated. Also, to prevent the mold from being lifted by the high ferrostatic pressure the top flasks are screwed together or weights are put on.

For this molding system, a new type of squeeze machine has been designed which is operated by compressed air and with which the squeezing is effected automatically. The impression of the top and bottom pattern plate is effected by means of a piston which carries the bottom pattern plate and moves upward and presses against a fixed presser head carrying the top pattern plate. The presser head consists of a plate, crosshead, and drawbars and can be swung around one of the drawbars which is designed as a supporting column.

It is said that all the operations except the introduction of the compressed air are done automatically. If boxes of various depths have to be molded the top presser plate can be adjusted accordingly and adjustments are possible for flasks of different lengths and widths. When molding deep and sharp castings the machine can also be used as a stripping-plate molding machine. It is claimed that the machine consumes very little air. (René Leonhardt, *Foundry Trade Journal*, vol. 52, no. 982, June 13, 1935, pp. 397–398)

INTERNAL-COMBUSTION ENGINEERING

The Thomas Engine

THE aim of the designer of the Thomas engine was to dispense with the usual clutch and gear box and produce a self-contained unit having a positive drive and providing an indefinitely variable speed ratio at the power shaft while the engine was functioning at any desirable constant speed. These characteristics were achieved by the evolution of a new type of driving gear to replace the normal crankshaft system for the conversion of the reciprocating motion of the piston into rotary motion.

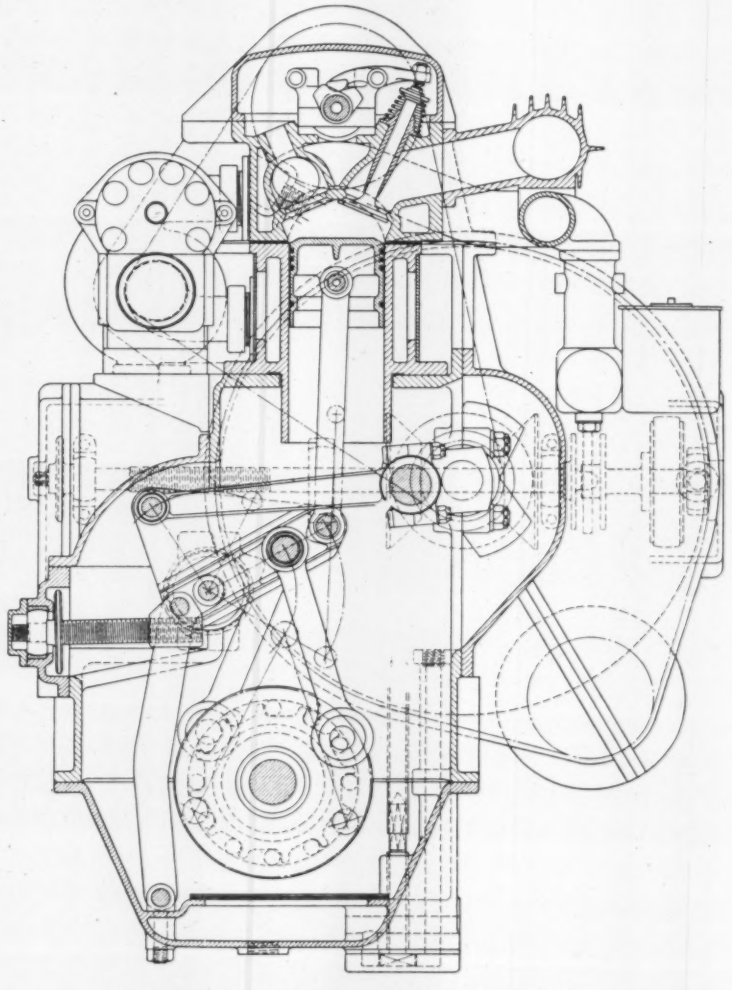


FIG. 1 CROSS-SECTION OF THOMAS ENGINE

It should be noted that apart from the driving gear the engine is strictly orthodox and conforms to modern practice. In comparison with a conventional engine of similar capacity with clutch and gear box, the Thomas engine is stated to give a reduction in weight and in space occupied, while tests have, it is claimed,

shown an increased overall efficiency.

The cross-section shown in Fig. 1 is of a six-cylinder unit with a bore and stroke of 70 mm and 101 mm, respectively, giving a swept volume of 2330 cu cm.

Each connecting rod is attached to the longer or horizontal arms of a bell-crank lever which oscillates about a fixed fulcrum pin. From the vertical arm of the bell crank a second connecting rod is coupled to the timing crankshaft on the opposite side of the engine. On the rear end of this crankshaft is mounted the light flywheel, and from an adjacent sprocket is taken by an inverted-tooth chain the triangulated drive for the overhead camshaft and the auxiliary units.

The horizontal arm of the bell-crank lever is provided with guides in which a crosshead is mounted which will slide, and from which depend two driving rods. At their lower ends the rods are attached respectively to the outer or driving members of a pair of unidirectional or free-wheel clutches keyed to the power shaft. The clutches are of conventional pattern with a series of rollers cooperating with a series of inclined tracks on the inner or driven member.

As the piston moves inward motion is imparted to the power shaft through one of the clutches and on the outward stroke through the other clutch. With a unit of three or more cylinders an overlapping movement is obtained, giving a continuous effort on the power shaft.

In the position shown in Fig. 1 with the crosshead located at the greatest distance from the fulcrum of the bell crank, the highest ratio between engine speed and power-shaft speed is obtained. When the crosshead is withdrawn until its pivotal axis is coincident with the axis of the bell-crank fulcrum, no motion is transmitted to the power shaft and a definite neutral position is thus obtained.

Between these two extreme positions an infinitely variable or stepless ratio is obtainable within the limit imposed by the particular design.

Each crosshead is connected by a link to the upper end of a long-radius lever mounted on a pivot in the sump. Movement of the levers through an arc, and consequent movement of the crossheads in relation to the bell-crank fulcrums to obtain a desired change of ratio, is effected by screwed shafts engaging nuts pivotally mounted on the levers. To accommodate the radial movement of the levers the outer ends of the screwed shafts are supported in self-aligning ball races. (*The Automobile Engineer*, vol. 25, no. 332, May, 1935, pp. 175–176, 4 figs.)

LUBRICATION

Nitric Acid in Used Motor Oils

IN 1932 (*Petroleum*, No. 23) Professor Graefe called attention to the formation of nitro-hydrocarbons from motor fuels. Graefe, using a motor oil poor in aromatic compounds, succeeded in isolating aliphatic nitro-compounds. The present author, using a benzene-benzol mixture, found in addition to nitric acid the presence of aromatic nitro-compounds. He offers the following explanation of the formation of nitric acid which in turn acts on the hydrocarbons and forms nitro-compounds.

In the course of the combustion of the fuel oil mixed with air under pressure in the engine cylinder (whether in explosion or Diesel engines), a part of the nitrogen of the air is converted into nitrous oxide. This, coming in contact with the oxygen of the air, forms nitrogen dioxide, and if water is present goes to nitric acid.

The present author went more thoroughly into a study of the occurrence of nitric acid and nitro-compounds in a motor. He found that when he attempted to determine by the xylol process the amount of water present in some used oils and motor residues, the water estimating column was filled with a brown vapor which when mixed with water was found to be nitric acid and could even be titrated (though this titration was not precise). Further investigation has shown that the presence of nitric acid could be established even when the brown vapors did not appear. In such cases, however, the amount of acid was smaller than before. The original article gives further details on tests with Pennsylvania, "American," and semi-German oils as well as mixtures of benzene and benzol, and the amounts of acid present in various oils after the motor covered a certain amount of mileage. (Dr. Kurt Ehlers in *Motorenbetrieb und Maschinen-Schmierung*, no. 4, 1935, appendix to *Petroleum*, vol. 31, no. 15, Apr. 10, 1935, pp. 2–3)

Factors for Rating the Quality of Lubricating Oil

THE author says that certain properties are used for determining the quality of the oil but that the reliability of these properties as indicators is admittedly none too good. He lists such properties but adds that all have a nebulous correlation to performance in actual engines in service. Moreover, the specifications usually cover an oil as it leaves the refiners and before entering the crankcase which is to be its base of operation for its life work.

Thus we are confronted before the engine starts with a goodly series of unknowns. Consider next what actually takes place within the motor. A new oil is introduced into the crankcase, one which has been carefully selected, one having the optimum values of the aforementioned indicators. Immediately after the starter is stepped on, these indicators begin to change, some rapidly, some slowly, some (like viscosity) first decreasing then increasing, and others progressively changing in the same general direction, but all changing until, after a few hours of operation, even the refiner himself would have difficulty in recognizing his product.

It is the fugitive character of these original specifications; the evanescent nature of the original properties; the lack of stability of the oil; that constitutes the greatest unknown in the problem of selecting and rating oils. One is interested in original properties only in so far as one thinks or hopes that they represent the properties existing in the oil after reasonable service. Otherwise we are purchasing something with a gaudy wrapper in the hope that the contents will be equally brilliant, but here neither buyer nor seller knows what is inside the golden exterior.

Briefly, therefore, lubricating oils in engines change their characteristics with usage and different types of oils change differently. Proofs of the second statement are available in the results of the engine tests which the Department of Mechanical Engineering at Pennsylvania State College in cooperation with the Pennsylvania Grade Crude Oil Association has conducted for the last two years. Some of these test data are reported in the original article. (H. A. Everett, Pennsylvania State College, paper before the Annual Meeting of the Pennsylvania Grade Crude Oil Association, June, 1935, abstracted through *National Petroleum News*, vol. 27, no. 25, June 19, 1935, pp. 28, 30, and 31)

MACHINE PARTS

Efficiency Formula for Worm Gears

TESTS on the efficiency of worm reduction gears have been made by the engineers of the De Laval Steam Turbine Co., Trenton, N. J. This was done with two gears identical in construction. One of the gears was run before, while the other was quite new. The gears were coupled together, one as a step-down gear, and the other as a speed-up

gear, and tested by having a carefully calibrated motor at one end and generator at the other. The results obtained are given in the original article, in which certain details of the tests are also explained. The first test showed a combined efficiency of the two gears in tandem as 91.54 per cent. When the power losses were taken into consideration it was found that one gear had an efficiency of 95.3 per cent and the other of 96.13 per cent.

To verify these results, the test was repeated with the power applied in the reverse direction, the efficiency x for gear No. 1 thus found being 95.8 per cent, while y for gear No. 2 was 96.7 per cent. Both gears showed improved efficiencies in the second test, as both had then been run more and the worms consequently had seated more perfectly in the bearing surfaces of the worm wheels. These tests, therefore, confirm the commonly accepted belief that worm gears improve materially in efficiency during the "running in" process.

A commonly used empirical rule for estimating the percentage efficiency of a worm gear is to subtract one-half of the ratio from 100. Thus

$$100 - \frac{6 - 3/5}{2} = 96.7,$$

which is an excellent approximation in the present case. A more rational formula for efficiency with the worm driving is

$$\text{Efficiency} = \tan L/\tan(L + l)$$

and with the wheel driving

$$\text{Efficiency} = \tan (L - l)/\tan L$$

L being the helix angle and l the angle of friction, equal to the angle whose tangent is the coefficient of friction.

A chart is given showing the coefficient of friction as a function of rubbing speed. This chart is taken from a recent paper by H. E. Merritt of England. In the present case, the rubbing speed at the pitch line figures out as 1259.6 fpm, for which the chart gives 0.0197 as the coefficient of friction. Applying this value for gear No. 2 with the worm driving, as in the second test, the efficiency by formula comes out as 96.57 per cent, which is sufficiently close to the value of 96.7 calculated from the test results. (*Pacific Marine Review*, vol. 32, no. 7, July, 1935, pp. 218–219, illustrated)

MACHINE-SHOP PRACTICE

Drilling Copper Tube Plates

THE drilling of copper is an unusual operation in most workshops and few data are available to those meeting it for the first time. On the other hand, in locomotive-boiler construction it is a matter of prime importance and daily experience.

Copper being a soft ductile material, the natural inference is that it would be easy to drill, and the power requirements small; actual experience at once disproves this, and the author puts forward the following notes to help those who have to meet this problem.

When seeking maximum production in drilling copper tube plates, three phases of this problem arise—power consumption, finish of the hole, and drill life between grinds.

Practically all investigations of the power consumption of twist drills have been summarized in expressions of the exponential type, a method which is not dimensionally correct. As twist drills of different sizes are dimensionally similar tools, with the same proportionate length of cutting edge to diameter and the same variation of cutting rake angles along this cutting edge, the cutting torque should be a function of d^2 times the feed per revolution, and of the material cut.

The author, however, insists on the basic accuracy of the assumption that, as a first approximation at least, torque varies as d^2 times the feed, and horsepower consumption at the drill as $N \times d^2$, or as the cubic inches of metal removed per minute. The author also derives an expression according to which the net kilowatt input to spindle motor equals constant times the cubic inches of metal removed per minute (without claiming novelty for this expression). In a table in the original article (Table 1) he gives the results obtained when drilling copper tube plates of four different Brinell hardness values with twist drills of various combinations of point angle and flute angle. From this and data of results obtained in drilling mild steel and medium-carbon steels the author draws three conclusions: Power consumption for drilling copper with twist drills of normal type (i.e., 29 deg helix and 118-deg point) is considerably more than for drilling steel; varying the point angle and helix angle of the drill alters the power consumption somewhat; but it is necessary to grind the cutting edge of the twist drill with a pronounced lip to achieve a very material drop in power consumption.

Comparison of the power-consumption figures for trepanning leads to the conclusion that whereas the power consumption of a twist drill and the trepanning tool were the same when operating on mild steel, the power consumption of the tool was much lower than a normal drill when cutting copper, but was the same as the lip-ground twist drill. The form of cuttings produced threw further light on this matter. When cutting steel both tool and drill produced long coiled cuttings that were freely ejected. The same result was produced on copper by the tool and the lipped drill, but the unlipped twist drills of all point angles and flute angles produced ragged cuttings, much distorted, in irregular lengths varying from long streaky pieces to short chips with apparently considerable friction of the cutting against the drill and against the hole, which was always rough in finish. Thus the large improvement in power consumption secured by lipping the drill for copper would appear to be chiefly due to reduction in useless work done on the cuttings after severance from the work piece and only in a minor degree to the change in cutting rake angle of the edge of the drill. As a final check theoretical values for the power consumption were obtained by using Stanton and Hyde's curves of cutting-pressure variation with cutting angle and integrating these graphically along the cutting edge of drills for various combinations of helix angle and point angle for copper, mild steel, and medium-carbon steel.

The other matters considered in the article are the finish of hole and drill life per grind. (*The Engineer*, vol. 160, no. 4149, July 19, 1935, pp. 59–60, 4 figs.)

PIPING

Annealing Pipe Welds by Induction

IT IS often desirable to stress-relieve fusion welds in a pressure-piping system. To do this properly the weld and the length of pipe on each side of it equal to about six times the wall thickness should be heated to a comparatively uniform temperature of 1100 to 1300 F which should be maintained for a period of time equal to one hour for each inch of pipe-wall thickness.

The author recommends doing this by induction, a process in which several turns of a conductor are wrapped around the pipe directly over the weld and 60-cycle current is passed through this winding. The details of the process are given in the original article.

It is claimed that the process operates in a satisfactory manner and that the weld temperature measured at any single point can be maintained within 20 F of the desired temperature with automatic control. The maximum point-to-point variation in temperature which results

from such conditions as differences in surface radiation, has been found to be approximately 50 F for the larger sizes of pipes used, that is, 12 to 16 in. The variation is less for the smaller pipes. The precision in temperature control precludes any danger of changing the nature of the grain structure by exceeding the critical temperature of the metal. (Paper before the American Welding Society by A. P. Frugell and D. H. Corey of Detroit Edison Co. in *Power Plant Engineering*, vol. 39, no. 7, July, 1935, pp. 405–406, 1 fig.)

POWER-PLANT ENGINEERING

Heat Losses in Lagged Steam Accumulators

GREAT fluctuations in demand for steam in modern large plants require the employment of correspondingly large steam-accumulator units. For example, an electrical central station which requires comparatively little steam during the night and early morning hours can usefully employ storage for the excess steam developed during that period to be used during the hours of maximum steam consumption.

The magnitude of steam consumption of the large central stations is indicated, for example, by the fact that the Berlin-Charlottenburg plant has in operation 16 vertical steam-storage plants located out of doors and therefore subject to all kinds of changes in weather conditions. The increase in demand for steam, however, makes it necessary to employ in these steam accumulators proper means of protection against heat losses, as otherwise the steam-storage system may be adversely affected.

The matter of protection against heat losses can be taken care of in several ways. If the heat insulation applied to accumulators is more or less hygroscopic the efficiency is reduced. A superior means of protection is by using dry insulation. In this case the heat-insulating mass is applied in as dry a condition as possible and is then additionally protected on both sides by means of a lead-coated sheet-iron jacket. This kind of insulation cannot take up moisture and operates in the same way all the time. The present article compares the two methods of heat insulation and comes to the conclusion that the first cost in the case of insulating material applied "wet" is 10 marks and for the sheet-iron lead-protected dry material 20 marks per sq m. In this connection it may be also mentioned that the insulating material applied wet has to be additionally protected against the worst weather conditions by an application of wall board or some such material. In spite of this, however, the protection does not last more than five to six years.

In the dry method of protection, the lead-covered jacket will ultimately also be destroyed by chemical or weather effects, but its life will be about 20 years so that a factor of depreciation of 5 per cent per annum can be used as against 20 per cent per annum for insulating material applied "wet."

Next the author considers whether a layer 10 cm thick of the dry type (i.e., with a leaded sheet-iron jacket) gives any material advantages in the operation of a steam accumulator. The conclusion to which he comes is that there is a decided advantage in using heat insulation on steam accumulators, but that the utmost care should be exercised in the selection of the heat-insulating material and its application. Proper protection of the accumulator against heat losses is a matter of great importance, but to discover it, it is necessary to resort either to calculation or to measurement of heat in the various parts of the machinery. It may, therefore, go long unnoticed, but affect the results of the operation of the plant. (Otto Krebs, *Feuerungstechnik*, vol. 23, no. 3, Mar. 15, 1935, pp. 30–32, 5 figs.)

Heat Saving Through Insulation of Flanges

THE author gives a general formula showing coefficient of saving of heat through the insulation of flanges as given by Eberle in *Zeitschrift des Vereines deutscher Ingenieure*, Vol. 52, 1908, p. 481. He further points out certain practical difficulties involved in the application of the Eberle formula, and states that because of these difficulties, it is the common practice, in considering heat insulation of piping and flat surfaces, to start with the coefficients of heat transfer or heat losses of *insulated* plates. This is done because it is comparatively easy to determine the factors in case of an insulated body. In considering heat insulation of flanges we have to work from the coefficient of heat saving because, on account of the peculiar characteristic of this insulation, a numerical determination of losses or precise measurement of these losses in the course of operation is impossible.

The author describes an installation for the determination of heat losses from bare and insulated flanges as well as the savings due to the use of the latter. This part cannot be abstracted because of lack of space.

As regards the economic importance of flange insulation the author cites an actual case of a pair of flanges 100 mm inside diameter operating in a superheated-steam system with an air temperature of 20 C.

According to a table in the original article the heat losses from a bare flange operating with saturated steam and a temperature difference of 300 C is Q_n = 1082 kcal per hr. For superheated steam we obtain $Q_n = 1.80 \times 1082 = 865$ kcal per hr. Assuming an average heat value of 5 marks per 10^6 kcal, we have a yearly charge due to this heat loss of 37.90 marks. The application of heat insulation reduced this heat loss to Q_i = 103 kcal per hr, equivalent to a yearly expenditure of 4.50 marks. With the saving on each pair of flanges of 33.40 marks per year, the cost of heat insulation will be rapidly covered. (Dr. of Engg. W. Weyh, communication from the Research Organization for Heat Insulation in Munich, abstracted through *Archiv für Wärmewirtschaft und Dampfkesselwesen*, vol. 16, no. 6, June, 1935, pp. 151–153)

STEAM ENGINEERING

Tests on High-Pressure Steam Turbines With Bleeding and Interstage Superheating

THESE tests were carried out by the author for a purchaser of turbines and covered tests on a back-pressure and a condensing turbine, both for an hourly steam throughput of about 100 tons.

The condensing turbine was located in the Caroline Mine Works of the Witkowitz Mining Co., and was in regular operation at the time of the tests. It is a three-housing unit with a divided low-pressure and is designed to take live steam at 120 atm abs and 480 C for interstage superheating to 360 C at the entrance to the intermediate-pressure part and for double-bleeding for feedwater preheating (while such double bleeding is provided, as a rule only low-pressure bleeding is used).

The turbine is fed from four Loeffler boilers having a total output of 210 tons of steam per hr at 130 atm and 500 C. The steam is admitted through two pipes to the main shut-off valves of the turbine, one valve of which is on the right and the other is on the left. The supply of steam to the turbine is controlled by four nozzle group valves actuated by oil under pressure and laid out for 10,000, 20,000, 30,000, and 36,000 kw, respectively.

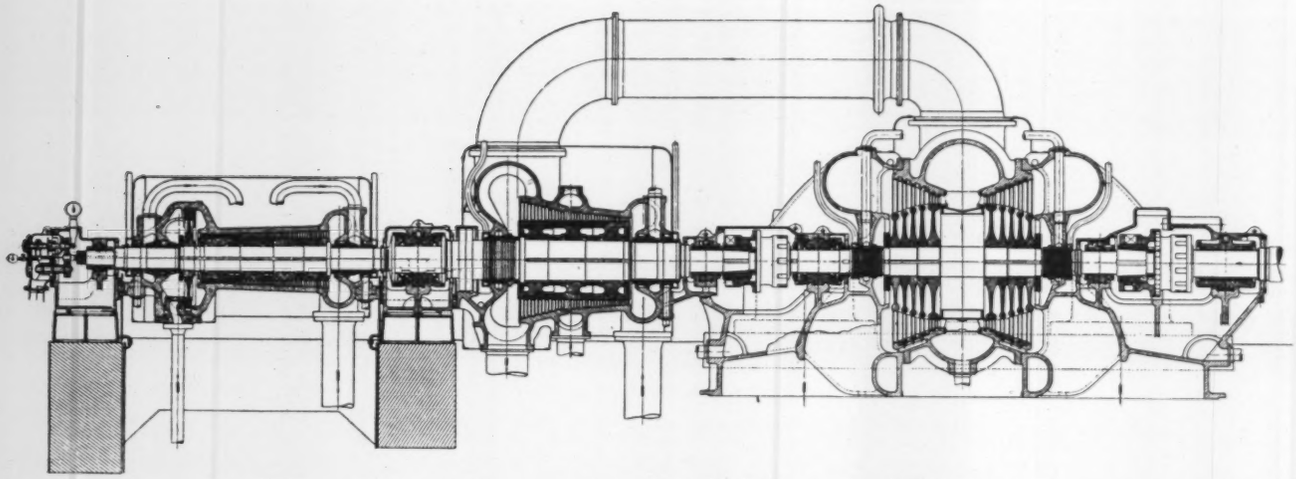


FIG. 2 GENERAL LAYOUT OF THE BROWN-BOVERI 36,000-KW CONDENSING TURBINE

These valves are located next to the turbine.

The interstage superheating of the working steam is effected by using live steam. The interstage superheater is located close to the turbine. The condensate is preheated in a surface heat exchanger to about 85 C by using bleeder steam taken from between the medium-pressure and the low-pressure sections, the heat exchanger being located in the pressure piping of the condensate pump. The condensate formed from the bleeder steam used for preheating is delivered to the main condensate system, and with the rest of the condensate flows to the boiler house through a common pipe. To make higher preheating possible a second bleeder source is provided after the eleventh stage of the medium-pressure section. During the tests this source of bleeding was shut off.

The turbine runs normally at 3000 rpm. A table in the original article gives a schedule of blading and a list of materials used in this turbine.

A notable feature of the turbine is that with the exception of a single double-row Curtiss wheel it is equipped in the first housing with reaction blading exclusively. The double-row Curtiss wheel makes it possible to utilize the considerable thermal head ranging from 120 atm abs and 480 C down to a vacuum, by interstage superheating in only three housings, which makes the design of the turbine simple and eliminates the loss through the two additional packing glands which the fourth housing would have produced. Moreover, a reduction of pressure and temperature in the Curtiss wheel produces a material reduction of load.

The high-pressure nozzles are located in chambers in the high-pressure housing (Fig. 2), otherwise the distribution of the pressure difference between the Curtiss wheel and the reaction elements is so organized that even at the topmost load of 36,000 kw the steam always expands first in the Curtiss wheel and is never led directly to the reaction (that is, bypassing the Curtiss wheel). The purpose of this arrangement is to keep away from the high-pressure housing the live steam which is admitted to the turbine with a temperature up to 500 C at the main inlet valve.

The data of the testing arrangements reported in the original article are omitted because of lack of space. Substantially, the following experimental results have been obtained.

THERMAL EFFICIENCY OF THE TURBINE

Table 1 gives the more important data of the tests. In the main test, No. 1, the steam consumption of the turbine was found to be 3.22 kg per kwhr, as measured at the generator coupling. The steam had a pressure of 120.7 atm abs and a temperature of 477 C at the main inlet valve to the turbine. Interstage superheating gave 350 C at the entry to the medium-pressure parts, with 0.054 atm abs pressure in the steam exhaust pipe and a reheating of the condensate to 86.2 C by the use of bleeder steam. The heat consumption of the turbine was 2477 kcal per kwhr at the couplings.

In order to make it possible to compare test data in so far as specific steam and heat consumption are concerned, all the data were recalculated to a uniform basis of state of live steam (120 atm abs and 480 C) and vacuum, tests Nos. 1 and 2 being further recalculated to an interstage superheat of 360 C. In this recalculation the variations of adiabatic head, moisture in the exhaust steam, and exit losses have been taken into consideration. Table 2 contains these recalculated values.

After all, the determining factor in so far as utilization of the steam is concerned is the thermal efficiency. This efficiency amounts to 34.72 per cent referred to output at the generator couplings when the turbine is operated with interstage superheating and condensate preheating by bleeder steam. The above value is notably high for a condensing-turbine installation. It falls off to 33.22 per cent when condensate reheating by bleeder steam is shut off, and falls to 32.63 per cent when, in addition, interstage superheating is cut out.

It appears, therefore, that the use of these two additional processes produces a material heat economy. Feedwater preheating by bleeder steam is particularly effective in this direction. On the other hand, interstage superheating reduces only slightly the specific heat consumption, which is due to the fact that the flow of working steam from the high-pressure section through the interstage superheater to the medium-pressure section is accompanied by an adiabatic drop in the high-pressure section. In this case it amounts to about 8 kcal per kg. Interstage superheating, however, has an operating advantage in that it reduces by about 6 per cent the content of moisture in the exhaust steam.

THERMODYNAMIC EFFICIENCY

The distribution of the total-heat head between the three housings is shown in Fig. 3. A substantial share of the total-heat head, namely, about 37 per cent, is utilized in the first housing. The thermodynamic behavior of the turbine in this housing is of interest because the

TABLE 1 GENERAL DATA OF TESTS

Test no.	1	2	3
Interstage superheating/preheating	with/with	with/without	without/without
Output at the generator terminals, kw	24,940	25,411	22,656
Output at the generator couplings, kw	26,050	26,522	23,822
Output at the turbine shaft (internal output of the turbine), kw	26,480	26,952	24,252
Measured total steam consumption of the turbo-generator, kg per hr	83,905	83,826	83,070
Measured specific steam consumption referred to output at the generator terminals, kg per kwhr	3.364	3.298	3.666
At the generator coupling, kw per kwhr	3.221	3.160	3.487
At the turbine shaft, kw per kwhr	3.169	3.110	3.425
Pressures, atm abs			
Head of main inlet valve of the turbine (average of left and right)	120.7	121.1	121.6
Back of governor valve 1 and in nozzle chamber 1	119.3	119.6	119.6
Back of governor valve 4 and in the nozzle chamber 4	116.7	116.5	115.6
Back of the governor valve 2 and in the nozzle chamber 2	114.3	112.9	104.1
Back of the governor valve 3 and in the nozzle chamber 3	39.8	39.4	38.3
In the chamber of the first wheel of the first housing	40.4	40.2	39.3
At outlet from the first housing	11.39	11.06	8.59
At inlet second housing	9.52	9.51	8.26
Between second and third housings	0.79	0.88	0.81
In exhaust steam pipes (average of the two exhaust-steam pipes)	0.054	0.054	0.052
Steam temperatures, C			
Head of main inlet valve of the turbine (average left and right)	477.2	476.5	474.7
In the nozzle chamber 1, corresponding to the throttling curve	476.0	475.6	473.7
Exit from first housing	227.5	227.7	204
Inlet to second housing	350.0	350.4	204
Exit from second housing	103.5	113.3	93
Temperature of condensate, C			
At inlet at preheater	33.7	33.7	32.5
At outlet from preheater	86.2	.....	.....
Heat content of the steam, kcal per kg			
Head of main inlet valve to the turbine	790.1	789.5	788.0
Exit from first housing	689.2	689.6	679.8
Inlet from second housing	754.2	754.4	679.8
Exit from second housing	641.3	645.7	.....
Specific heat consumption of the turbine, kcal per kwhr			
For output at couplings	2,477	2,593	2,634
For internal output	2,437	2,552	2,588
Thermal efficiency of turbine, per cent			
In terms of output at couplings	34.72	33.17	32.65
In terms of internal output	35.29	33.70	33.23

TABLE 2 RECALCULATED VALUES ENABLING TO COMPARE AMONG THEM THE FIGURES IN TABLE 2

Test no.	1	2	3
Interstage superheating/preheating	with/with	with/without	without/without
Specific steam consumption of the turbine with preheating, kg per kwhr			
Output at the coupling	3.200	3.141	3.478
Internal output	3.148	3.091	3.416
Specific heat consumption of the turbine with interstage superheating, kcal per kwhr			
Output at the coupling	2,477	2,589	2,636
Internal output	2,437	2,548	2,589
Thermal efficiency of the turbine, per cent			
As referred to output at the coupling	34.72	33.22	32.63
As referred to in internal output	35.29	33.75	33.22

construction investigated by Brown Boveri Company, apart from the use of the Curtis wheel, works only with reaction blades. From the ratio of the internal drop determined by temperature and pressure measurements, to the adiabatic drop, the internal efficiency can be determined. This was found to be about 73 per cent (tables 4 and 5), in the first housing in all three tests. About one-half of the high-pressure head has been utilized in the Curtis wheel. The vol-

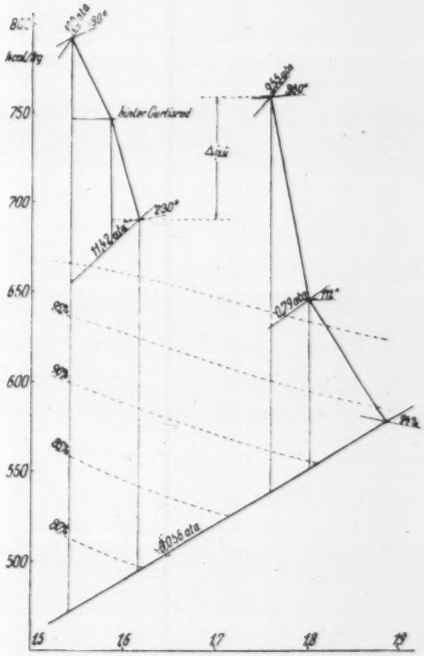


FIG. 3 TOTAL HEAT-ENTROPY DIAGRAM
(*Hinter Curtissrad* = behind the Curtiss wheel.)

ume of steam at the inlet is about 0.6 cu m per sec.

The efficiency of the Curtiss wheel in all the tests was found to be between 60 and 62 per cent. It is necessary, however, to point out that there was a certain amount of doubt as to the measurement of temperature carried out in the chamber back of the Curtis wheel.

The reaction elements of the high-pressure cylinder having a Parsons coefficient of about 3250 work with an internal efficiency of about 80 per cent.

In the second housing the flow of the working steam is wider, while the rim flow which causes the losses is comparatively narrow, so that the conditions are more favorable for the proper utilization of the steam. The internal efficiency calculated from the temperature and the pressure gives in the tests with interstage superheating approximately 88 per cent, Table 3, with a Parsons coefficient of 3450, which corresponds to a specific peripheral velocity of

$$\frac{1}{91.53}\sqrt{\frac{\Sigma u^2}{H_2}} = 0.64$$

TABLE 3 DATA OF TESTS IN OPERATING WITH AND WITHOUT BLEEDING BUT WITH INTERSTAGE SUPERHEATING

Test no.	1 with	2 without bleeding
Internal output of the turbine, kw	26,480	26,952
1 Housing computed from pressure and temperature[1]	9,745	9,642
2 Housings computed from pressure and temperature[1]	10,625	10,220
Total	20,370	19,862
All three housings	6,110	7,090
1 Housing		
Adiabatic drop computed from state in nozzle chamber 1, kcal per kg	136.1	137.0
Adiabatic output, kw	13,280	13,350
Thermodynamic efficiency computed from temperature and pressure, per cent	74.0	72.9
2 Housings		
Adiabatic drop computed from state in nozzle chamber 1, kcal per kg	127.8	123.3
Adiabatic output, kw	12,470	12,020
Thermodynamic efficiency computed from temperature and pressure, per cent	88.3	88.2
3 Housings		
Adiabatic fall computed from state in nozzle chamber 1, kcal per kg	93.8	98.7
Amount of steam, kg per hr	76,660	83,826
Adiabatic output, kw	8,362	9,618
Thermodynamic efficiency in terms of internal output, per cent	73.0	73.7
Thermodynamic efficiency of the turbine		
In terms of internal output, per cent	77.6	77.1
In terms of output at the couplings, per cent	76.4	75.8

[1] Packing gland losses have been considered here.

TABLE 4 DATA OF TESTS OF OPERATION WITH AND WITHOUT INTERSTAGE SUPERHEATING AND WITHOUT BLEEDING

Test no.	2	3
Interstage superheating	with	without
Adiabatic drop for the entire turbine in terms of the state in nozzle chamber 1, kcal per kg		
Housing 1	137.0	148.1
2 and 3 housings	218.9	183.3
Total	355.9	331.4
Steam consumption with adiabatic expansion, kg per kwhr	2.417	2.595
Thermodynamic efficiency of the turbine, per cent		
In terms of internal output	77.7	75.7
In terms of output at the couplings	76.5	74.4
Drop utilized in the turbine corresponding to internal output, kcal per kg	276.5	251.0
Part utilized in the 1 housing	99.9	108.2
Part utilized in the 2 and 3 housings	176.6	142.8
Heat content of steam in the exhaust pipe corresponding to the head utilized, kcal per kg	577.8	537.0
Moisture in the exhaust steam, per cent	5.9	12.8
1 housing thermodynamic efficiency computed from pressure and temperature, per cent	72.9	73.0
2 and 3 housings thermodynamic efficiency corresponding to the drop of heat utilized, per cent	80.7	77.9

where H_2 denotes here the adiabatic drop in the second housing.

The internal efficiency of the low-pressure section is determined from the internal output of the low-pressure section because of the presence of moisture in the exhaust steam. The internal output is computed as the difference between the total internal output of the turbine and the sum of the internal outputs of the first and second housings. It was found that the internal efficiency of the low-pressure section of the turbine as computed with interstage superheating amounted to about 73.5 per cent. The volume of exhaust steam was about 560 cu m per sec and the water content of about 6 per cent.

In test No. 3 without interstage superheating, Table 4, all attempts to divide the measurements between the medium-pressure and low-pressure parts had to be given up, because there was no noticeable superheat of the steam at the exit from the third housing and hence the state of the steam could not be determined. In order, however, to be able to compare the thermodynamic behavior of the turbine with and without interstage superheating, test No. 2 was recomputed for Table 4 in the same manner as test No. 3 to which reference has been made.

With the interstage superheating cut out, the efficiency of the second and third sections falls off from 80.7 to 77.9, and without interstage superheating the water content of the exhaust steam becomes 12.8 per cent. This water content is then so high that there is a danger of erosion of rotor blades. For continuous operation, therefore, interstage superheating becomes absolutely necessary.

The thermodynamic efficiency for the entire turbine operating with interstage superheating is then about 76 per cent when referred to output at the couplings, Table 3. In considering this figure it is necessary to bear in mind that in this case the adiabatic drop was taken as the sum of three partial drops, namely, high-pressure, medium-pressure, and low-pressure sections. The total adiabatic output, however, is that much greater, which makes the thermodynamic efficiency of the turbine that much smaller the more the total heat drop is subdivided. This can be brought out also by a comparison of the efficiency determined for the entire turbine (test No. 2, in Table 3) with the values for the same test calculated according to Table 4. Values in Table 3 are somewhat lower than those in Table 4 because in the latter the total drop has been divided into two as compared with three partial drops shown in Table 3.

The usual practice is to calculate the total efficiency of a pure condensing turbine from the live-steam state to a vacuum on the basis of the total adiabatic drop. This cannot be done in the turbine being investigated because of the presence of interstage superheating and bleeding. If, however, one considers the heat recovered because of the non-adiabatic expansion in the high-pressure section and if one takes the medium- and low-pressure sections together as a single unit, it will be found that the efficiency for the entire turbine is about 80 per cent of the output at the generator coupling.

In connection with these figures for thermal and thermodynamic efficiencies it is necessary to bear in mind that in the tests the turbine ran with partial load. One nozzle valve was completely closed and the other throttled down. It is legitimate to assume that the values with higher loads on the turbine would be more favorable. In an early issue it is hoped to publish the results of tests on a 12,000-kw bleeder turbine built by the German General Electric Co. (Prof. E. Josse in *Elektrizitätswirtshaft*, vol. 34, no. 13, May 5, 1935, pp. 273–279, 4 figs.)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Slag Tapping of Boiler Furnaces

To the Editor:

The method of ash removal, described by J. H. Strassburger,[1] has been applied to more than 100 furnaces since its first commercial use at Buffalo in 1926, but the installations described by Mr. Strassburger are the only ones using this method on boilers fired by blast-furnace gas and pulverized coal, and are of special interest for that reason.

Mr. Strassburger states that when firing blast-furnace gas alone over week-ends the bed freezes over. Furnace temperatures with blast-furnace gas are materially lower than with pulverized coal but the dust in the gas usually has a low melting temperature. It is stated that the rate of heat liberation is from 10,500 to 16,500 Btu per cu ft per hr, which is low for furnaces having this amount of furnace cooling. It would be interesting to know the heat liberation and excess air during these week-end periods, and if the furnaces have been operated on gas alone on the highest week-day load, for several days, or long enough to accumulate an appreciable quantity of dust on the bed, and, if so, what experiences were recorded.

The fusing temperature of the dust and of the coal ash and the proximate analysis of the coal would also be interesting additions to the data given.

The coal normally obtained in the vicinity of Weirton does not contain an excessive amount of pyrites, and the blast-furnace gas dust contains none, so that the troubles caused by sulphide in the bed would not be expected to be serious. It is therefore not surprising that refractory floors have given reasonable life. Other units in that vicinity have refractory floors in furnaces operating at much higher rates of heat liberation.

The paper gives a clear picture of the steps in the development of the floor details and the author is to be highly commended for the logical improvement shown in the later furnaces. While this type of floor is suited to the conditions at this plant, it would be too optimistic to think that it would be satisfactory for other furnaces with larger floor dimensions, higher rate of heat liberation, and burning coal containing a greater amount of pyrites.

R. M. Hardgrove.[2]

To the Editor:

One of the most interesting facts regarding the installation of the boiler furnaces at Weirton Steel Company is that they are fired with horizontal, turbulent-type burners. It has, in general, been accepted that burners for slag-tap furnaces should be arranged to fire downward so as to impinge on the slag pool. The burners are located approximately 10 ft above the furnace floor and under the expected ratings of 175 to 200 per cent would be considered a satisfactory setting for dry-bottom operation.

The calculated temperature of the gases entering the boiler-tube bank, when operating with 16 per cent CO_2 at 220 per cent of boiler rating, is 2350 F and at 300 per cent rating, 2600 F. Therefore, unless the ash has an exceedingly low fusing temperature, it would hardly be expected that it would be possible to tap slag in a molten condition successfully at 220 per cent rating. It is apparent that the flame shields the heat-absorbing surfaces of the boiler and water wall and that the radiation from the underside of the flame supplies sufficient heat to make it possible to slag the ash.

In connection with some experimental studies, four carloads of coal having an ash-fusion temperature of 2800 F were used in one of the units at Weirton Steel Company, and the ash was successfully slagged and drawn off in a molten state. It is possible that the ash in the furnace remaining from the usual run of coal had a fluxing action on the high-fusion temperature ash, but it was thought that the amount of high-fusion-temperature ash used was sufficient to remove the old ash and give a real indication of the effectiveness of this simple arrangement for slag tapping.

It is my understanding that no difficulty has been experienced with the side walls pushing out, as has been the case with a great many slag-tap furnaces. This is probably due to care being taken to dig a trench in the hardened slag adjacent to the side walls, if the boiler has been shut down long enough for the slag to become solid.

The successful operation of these slag-tap furnaces points a way to changes in existing installations where it is desirable to change from dry bottom to slag-tap bottoms without an excessive expenditure, for the rather expensive furnace-bottom construction commonly in use with slag-tap furnaces.

James W. Armour.[3]

Venturi and Weir Measurements

To the Editor:

The paper by Allen and Hooper[4] is valuable in the water-measurement field because it provides a basis for checking large-capacity meters in service for extended periods. Professor Allen's ingenious method, of rating two large meters by differential steps against a weighing tank of relatively small capacity, has made this practicable.

In connection with this paper it may be well to bring out that the soft waters of New England are notoriously conducive to rapid tuberculation and growth formations on pipe interiors. Even so, Fig. 3 of the original paper shows that more than six years is required to produce a venturi-coefficient variation of plus-or-minus one-half per cent. This change is seen to proceed at a steady rate so that the venturi meter evidently can be relied upon within one-quarter per cent with either calibration or recondi-

[1] "Slag Tapping of Flat-Bottom Boiler Furnaces," by J. H. Strassburger, Mechanical Engineering, June, 1935, pp. 367-368.

[2] Engineer in charge of design, Babcock & Wilcox Co., New York, N. Y. Mem. A.S.M.E.

[3] Vice-President, Engineering Manager, Riley Stoker Corp., Worcester, Mass. Mem. A.S.M.E.

[4] "Venturi and Weir Measurements," by Charles M. Allen and Leslie J. Hooper, Mechanical Engineering, June, 1935, pp. 369-374.

tioning periodically where tuberculation is apparent. This is in marked contrast to the wide and unpredictable variations in the observed weir coefficients.

Numerous examples can be cited of venturi tubes in various sections of the country, that have been in service for long periods, which showed neither tuberculation nor deposit upon examination. In this list are tubes for raw sewage as well as for water. For example, see *Engineering News-Record* for January 11, 1934, in which an examination by C. E. Keefer, Principal Assistant Engineer, Bureau of Sewers, Baltimore, showed five 42-in. meters for raw domestic sewage (of the same manufacture as the one tested) at Baltimore to be "perfectly clean and smooth on the insides and no indication that the cast iron had disintegrated," although they had been in service for periods ranging from 13 to 23 years.

In those water systems known to be subject to serious tuberculation, periodic examination of venturi tubes is recommended for maintaining their initial accuracy. Venturi tubes are available with adequate inspection openings to facilitate such examination. In general, we consider it preferable to maintain a venturi tube in proper condition, in which case its initial coefficient also will be maintained. If this is done, repeated calibrations will be unnecessary.

It should be observed that unless the bronze-lined throat of a standard venturi tube is affected, considerable tuberculation and deposition in the inlet portions can be present without appreciably altering the coefficient.

The 36-in. by 16-in. venturi tube tested is one of the first half-dozen to be manufactured, more than forty years ago. This tube has been exposed to unusually severe tuberculation and may well have been abnormally rough even after scraping in 1921. In addition, we understand that a number of extra openings have been made for pitot tubes, also a 12-in. branch is taken closer to the inlet of the tube than would be recommended. In view of this, there seems to be a real question as to how nearly standard this venturi-tube installation is at present. The accumulated experience of the manufacturer of this tube indicates that a coefficient of 0.990 or higher exists for a standard 36- by 16-in. venturi tube properly installed in a reasonably smooth main.

CHAS. G. RICHARDSON.[5]
ED S. SMITH, JR.[6]

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Industrial Relations

EXECUTIVE GUIDANCE OF INDUSTRIAL RELATIONS. By C. Canby Balderston. Research Studies 25, University of Pennsylvania Press, Philadelphia, Pa., 1935. Cloth, 6 × 9 in., 435 pp., $3.75.

REVIEWED BY L. P. ALFORD[1]

THIS volume is the result of case studies of the personnel methods and results of 25 representative concerns. They are among the 200 largest corporations in the United States. To aid the reader in judging the value of this survey information on "phases of management that affect employees," the concerns whose methods and records were explored are: American Rolling Mill; Baltimore and Ohio Railroad; Bell Telephone of Pennsylvania; California and Hawaiian Sugar Refining; Columbia Conserve; Commonwealth Edison; E. I. du Pont de Nemours; Eastman Kodak; Edison Electric Illuminating of Boston; General Electric; Goodyear Tire and Rubber; Hart, Schaffner, and Marx; Ilg Electric Ventilating; Irving Trust; Kohler; Leeds and Northrup; R. H. Macy, Peoples Gas Light and Coke; Procter and Gamble; Rocky Mountain Fuel; Samarkand; Standard Oil of New Jersey; Standard Oil of California; Studebaker; and Westinghouse Electric and Manufacturing Co.

The book has been planned to give case studies of 25 pioneer programs, factors underlying personnel decisions; a selected composite program, an appraisal of methods and conflicting concepts, analysis of industries represented, and personnel standards.

The spirit in which the work has been planned is revealed in the following statement: "These chapters do not attempt to provide a solution for the entire register of social ills, but merely a portrayal of the nature and effects of certain developments in employer-employee relations. The latter vitally affect the ability of a firm to discharge its obligations to those who depend upon it for a job (i.e., for a living, and a chance to work). To call them 'obligations' begs the question of course, but it is becoming increasingly clear that if industry does not take care of its own, the consequences will be fraught with disturbing and alarming incidents for owners and workers alike. Consequently, industry needs a clear vision of its problems."

The studies are well done although, of necessity, there is a similarity in their form of presentation that becomes somewhat tiresome as one reads them one after another. That portion of the book that commands deserved attention is Part 2, inferences. Here the author expresses his own views for which he accepts full responsibility. Three chapters are included: Factors underlying personnel decisions, a selected composite program, and an appraisal of methods and conflicting concepts. Of these the reviewer particularly recommends the third, in which a number of important problems are presented and discussed: Are personnel programs a sop to labor? Do personnel policies reflect an enduring philosophy of human relations?

The annual total expenses charged against personnel activities were found to vary from $41 to $102 per capita. Could this money have been better spent to a greater benefit of employee and employer? This question cannot be satisfactorily answered, but a few observations are pertinent in its consideration. The concerns studied "apparently pay annual wages higher than the averages of their respective industries." They have kept pace with the reduction in the frequency of accidents during the last

[1] Consulting Engineer, New York, N. Y. Past Vice-President, A.S.M.E.

[5] Manager, Venturi Department, Builders Iron Foundry, Providence, R. I.

[6] Hydraulic Engineer, Builders Iron Foundry, Providence, R. I. Mem. A.S.M.E.

decade. Twenty-two give some protection against the death of the wage earner; nineteen have some form of old-age pension.

Against these advantages must be placed certain weaknesses. These plans did not provide for job security. They are not a complete defense against unsympathetic supervision and unscrupulous ownership. Probably the most serious mistake made by personnel organizations during the years of prosperity was to encourage stock purchases by employees. It was a dangerous procedure as the results have amply proved.

This valuable chapter on appraisals closes with a consideration of conflicting concepts concerning personnel relations. Among them are:

Opposition vs. community of interest between employer and employee.

The sharing of management vs. its concentration in leaders of proved ability.

Company unions vs. union-management cooperation.

Economic determinism as applied to wages vs. human approach to wage setting.

Here are brought out certain differences in opinion and points of view which cannot be resolved by a factual study, but must be taken into account along with numerous imponderables. This is so because the questions concern human beings.

One other feature deserves emphasis, for it partially answers the question, What has happened to personnel during the depression? Professor Balderston found, from the cases studied, this answer: The depression of the 1930's brought many changes in detailed technique, but few in fundamental policies. The personnel departments of our chosen companies were adjusted to the shift of emphasis from the building up of a force to keeping it efficient even while it was being decimated by layoffs.

Books Received in Library

BOSCH KRAFTFAHRTECHNISCHES TASCHENBUCH. Fourth edition of "Technischen Tabellen." By Robert Bosch A.G., Stuttgart; V.D.I. Verlag, Berlin, 1935. Leather, 4 × 6 in., 2.50 rm. This remarkably compact pocketbook contains a well-chosen collection of data frequently wanted by the automotive engineer. The necessary physical, electrical, chemical and mechanical data, information about fuels, lubricants, internal-combustion engines, electrical equipment for automobiles and aircraft, and general data on racing records, etc., are presented.

COMBUSTION-ENGINE FUELS AND HEAT. STATIONARY DIESEL ENGINES. DIESEL-ENGINE DETAILS AND MANAGEMENT. By J. Vanderdoes, L. H. Morrison, and C. T. Baker. International Textbook Co., Scranton, Pa., 1935. Leather, 5 × 8 in., illus., diagrams, charts, tables. First two volumes $1.75; last volume $2. "Combustion-Engine Fuels and Heat" discusses the nature of heat, its effects, thermodynamics, heat and work, combustion, liquid and gaseous fuels, and the principles of the internal-combustion engine. "Stationary Diesel Engines" describes the various types and their construction. "Diesel Engine Details and Management" describes the parts of these engines and their auxiliaries, and explains the operation, maintenance and repair. The three volumes present a practical course in Diesel engines; they are clearly and simply written, and well adapted to the needs of students and operators.

DEUTSCHES MUSEUM, ABHANDLUNGEN UND BERICHTE, Vol. 7, part 1. Kulturförderung durch Technik und Wissenschaft, by J. Zenneck. V.D.I. Verlag, Berlin, 1935. Paper, 6 × 8 in., 20 pp., illus., 0.90 rm. A popular lecture in which, by means of selected examples, attention is called to some of the contributions of science and engineering to civilization. The microscope, photography, radio, and the facilitation of transportation are the examples used.

EINZELKONSTRUKTIONEN AUS DEM MASCHINENBAU, Part 5. Edited by C. Volk. ZAHNRÄDER, Part 2, Stirn- und Kegelräder mit schrägen Zähnen; Part 3, Schraubgetriebe (Hyperbolische Räder, Schraubenräder, Schneckengetriebe). By A. Schiebel. Third edition. Julius Springer, Berlin, 1934. Paper, 6 × 11 in., 122 pp., illus., diagrams, charts, tables, 9 rm. The first section of this treatise on gears, published in 1930, dealt with straight-tooth spur and bevel gears. The present volume discusses helical, spiral-bevel, and worm gears. The theory, design, and production of the various types are discussed in detail in a practical, comprehensive manner.

FACTORY ORGANIZATION AND ADMINISTRATION. By H. Diemer. Fifth edition. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 412 pp., illus., diagrams, charts, tables, $4. This standard text has been revised to include the advances that have been made during the past decade. The book has a wide scope, covering everything from factory location and building to department organization.

FESTIGKEITSLEHRE MITTELS SPANNUNGSOPTIK. By L. Föppl and H. Neuber. R. Oldenbourg, Munich and Berlin, 1935. Paper, 6 × 9 in., 115 pp., illus., diagrams, charts, tables, 6.60 rm. The lack of any German book on photoelasticity has provided the reason for this small work, which presents the theoretical principles of the method, describes the interpretation of its results and shows its uses in studying the strength of materials. The book is based on the experience of the mechanical-engineering laboratory of the Munich Technical High School.

MACHINE DESIGNERS' GUIDE. By K. W. Najder. Edwards Brothers, Ann Arbor, Mich., 1935. Cloth, 5 × 9 in., 198 pp., diagrams, charts, tables. Formulas, mechanics, graphics, strength of materials, and examples. A collection of mathematical and mechanical tables and formulas frequently needed by machine designers and draftsmen. The formulas avoid higher mathematics and the book is intended for designers of limited engineering education.

LE MOTEUR À EXPLOSIONS, Vol. 1. By R. Devillers and P. Mercès. Third edition. Dunod, Paris, 1935. Cloth, 8 × 11 in., 703 pp., illus., diagrams, charts, tables, cloth, 410 frs.; paper, 3.85 fr. This treatise offers, in two volumes, a comprehensive discussion of the internal-combustion engine, especially as applied to automobiles and aircraft. The results of recent theoretical and experimental investigations are included in this new edition, which contains much of value to the designer and manufacturer.

NATIONAL PHYSICAL LABORATORY, Report for the year 1934. Department of Scientific and Industrial Research. His Majesty's Stationery Office, London, 1935. Paper, 8 × 11 in., 260 pp., illus., diagrams, charts, tables, 13s. This volume contains a concise report on the work done in the fields of physics, electricity, radio, meteorology, engineering, metallurgy, aerodynamics, and hydrodynamics. The various investigations are described briefly and the results summarized. A list of papers published by the laboratory and the staff is included.

PRACTICAL MECHANICS OF MOTION. By J. F. Mangold. McGraw-Hill Book Co., New York and London, 1935. Cloth, 5 × 8 in., 263 pp., diagrams, tables, $2. A textbook for trade schools which provides a simple, practical treatment of mechanics. A large amount of basic theory is developed and applied to problems, many of which are within the experience of the student. The text contains a large number of solved illustrative problems.

PRINCIPLES OF MOTOR FUEL PREPARATION AND APPLICATION, Vol. 2. By A. W. Nash and D. A. Howes. John Wiley & Sons, New York, 1935. Cloth, 6 × 10 in., 523 pp., illus., diagrams, charts, tables, $8. The first volume of this important treatise dealt with the production of gasoline, benzine, alcohols, and other motor fuels. The present volume deals with their properties. Chapters are devoted to analysis, sulphur content, gumming properties, volatility requirements, knock ratings, specifications, aviation fuels, and Diesel engines and fuel oils. Numerous references accompany each chapter. The work is a valuable addition to the literature of the subject.

RISE OF MODERN PHYSICS. By H. Crew. Second edition. Williams & Wilkins Co., Baltimore, 1935. Cloth, 5 × 8 in., 434 pp., illus., diagrams, tables, $4. This is an excellent history of physics from the Renaissance to recent times, written in entertaining fashion and making no requirements of technical knowledge upon the reader. The book is intended for undergraduates, but will be equally useful to all those interested in the history of science. Three new chapters, dealing with the inertia of electricity, the rise of modern spectroscopy, and restricted relativity have been added to this edition; and errors in the text have been corrected.

SCIENCE AND THE PUBLIC MIND. By B. C. Gruenberg, with a foreword by J. C. Merriam. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 8 in., 196 pp., charts, tables, $2. This interesting book reports the results of an investigation of the place of science in adult education which Dr. Gruenberg has made at the invitation of the American Association for Adult Education. The place of science in modern life, the means and methods by which science may be brought to the public, and the educational system are

considered; and a program suggested which would further general understanding of the importance of science to the people as a whole.

STEAM TURBINES. By E. F. Church. Second edition. McGraw-Hill Book Co., New York and London, 1935. Cloth, 6 × 9 in., 327 pp., illus., diagrams, charts, tables, $3. This textbook aims to provide a short but thorough course for students in engineering colleges. The general form and principal characteristics of a variety of turbines are presented, and thermodynamic principles are applied to the calculation of the flow of steam through the nozzles and blade passages, the changes in its energy, pressure and volume, and to the various factors that affect efficiency. The new edition includes material on supersaturation, the flow of wet steam, runaway speed, and stalling condition, and has been revised throughout.

VERSUCHSFELD FÜR MASCHINENELEMENTE DER TECHNISCHEN HOCHSCHULE BERLIN, Heft 11. UNTERSUCHUNG VON STOPFBÜCHSEN-PACKUNGEN UND MANSCHETTENDICHTUNGEN FÜR HOHEN HYDRAULISCHEN DRUCK. By H. Gronau. R. Oldenbourg, Munich and Berlin, 1935. Paper, 8 × 12 in., 26 pp., illus., diagrams, charts, 4 rm. This report covers investigations of packings for stuffing boxes and hydraulic cylinders, carried out in the testing laboratory of the Berlin technical high school. The imperviousness, leakage losses, and frictional resistance of nine popular packings were accurately determined, and the effect on the properties of variations in pressure, speed, and temperature investigated.

WIRTSCHAFTLICHKEIT IM DAMPFKESSEL-BETRIEBE, Arbeitshilfen zur wirtschaftlichen Überwachung von Dampfkessel-Anlagen. By H. Kolbe. Wilhelm Knapp, Halle (Saale), 1935. Paper or Cloth, 7 × 10 in., 68 pp., diagrams, charts, tables, paper, 5.20 rm.; cloth, 6.80 rm. This manual is intended to assist the engineer in charge of a boiler plant to analyze its capacity and deficiencies, and to determine the most economical operating conditions. Methods are given for investigating firing and fuels and the losses in firing, flue gases, steam, radiant heat, etc. The determination of steam costs and methods of accounting are also considered.

WHAT'S GOING ON

This Month's Authors

RUSSELL H. ANDERSON, who contributes to this issue the leading article on "The Technical Ancestry of Grain-Milling Devices," has been curator of the department of agriculture, textiles, and forestry of the Museum of Science and Industry in Chicago, since 1929. Dr. Anderson's special interest is in the field of technological and agricultural history. His undergraduate and graduate work was done at the University of Illinois where he received the degree of Doctor of Philosophy in history and where he was a member of the history faculty for three years. He has also taught at the State Teachers Colleges at Peru, Nebraska, and Greeley, Colorado.

C. HAROLD BERRY, member, A.S.M.E., Gordon McKay professor of mechanical engineering at Harvard University, has directed his attention for several years to the properties of compressed liquid water that become important to know about in working with problems of high-pressure-steam power plants. Professor Berry received the degree of M.E. from Cornell University in 1912 and his M.M.E. in 1916, and served on the faculty of that university until 1918, when for a year he was engaged in Army Ordnance Inspection. He spent six years with the Detroit Edison Co., and later became associate editor of "Power." Since 1928 he has been on the faculty of Harvard.

J. T. NICHOLS, who presents this month a study of metallic heat insulation, is a member of the A.I.E.E. and the A.S.R.E. He is assistant manager of the research laboratory of the American Sheet & Tin Plate Co., Pittsburgh, Pa., where much of the development work on sheet-metal insulation described in the paper has been done. The paper is to be read at a meeting of the A.S.M.E. Metropolitan Section, New York, N. Y., in October.

"The Creep of Steels as Influenced by Macrostructure" is contributed by L. L. WYMAN, who, since 1929, has been a research metallurgist at the research laboratory of the General Electric Co. He received his B.S. from the University of Minnesota in 1922 and the degree of Ch.E. in 1923. For a year he taught metallurgy at the Oklahoma School of Mines, and then for five years was metallurgist for the Harrison wire division, incandescent lamp department, General Electric Co. Mr. Wyman has presented other papers on other metallurgical subjects before the A.I.M.E. and the A.S.M.E.

C. D. BLACKWELDER, member, A.S.M.E., who writes on "Stream Pollution and Textile Wastes," has been associated since 1922 with J. E. Sirrine & Co., engineers, Greenville, S. C., as chemical and mechanical engineer. His work has been in the consulting and designing fields, dealing with water-works plants, pumping-station filtration and softening plants, textile and trade-waste disposal plants, and textile bleaching, dyeing, and printing plants. He was at one time connected with the South Carolina Cotton Oil Co., and for nine years with the American Machine and Manufacturing Co. He served the latter company for several years as resident engineer in India in full charge of the company's interests. He is the author of several other technical papers presented before scientific societies.

G. H. VAN HENGEL and JOHN D. STARKWEATHER, co-authors of the article "An Oil Manometer," are associated with the production department of The Detroit Edison Company. Mr. Van Hengel, a member of the A.S.M.E., has specialized in power-plant work and aviation and is at present much interested in steam condensers and auxiliaries. He was educated abroad and holds a degree from the University of Delft, The Netherlands. Mr. Starkweather, a junior member of the A.S.M.E., is a graduate of Sheffield Scientific School, Yale University.

HARRY BENSON, author of the article on "Effective Handling of Quality Complaints," has been associated with Cheney Brothers, manufacturers of silk in South Manchester, Conn., for the past 22 years. He has served in turn as timekeeper, production engineer, production manager, technical superintendent, and quality-control and inspection superintendent. He has also served on the committee for establishing standard methods of inspection by the Federation of Textiles, and was appointed chairman of the committee for establishing standard lighting for inspection of broad goods.

F. J. FEELY, the author of "Quality Control in Manufacturing," is superintendent of the radio and instrument shop of the Western Electric Co., and was formerly superintendent of the Kearny Works of the same concern. Mr. Feely's experience has been in manufacturing development and factory layout. Mr. Feely's paper, which was presented at the Semi-Annual Meeting of the A.S.M.E. at Cincinnati in June as part of a symposium on Quality Control, was discussed by H. F. DODGE who is a member of the technical staff of the Bell Telephone Laboratories, New York, N. Y., and by J. M. JURAN, chief of inspection results department, Western Electric Company, Chicago, Ill., whose contributions follow Mr. Feely's.

"The Engineer and the Housing Problem" is a review by EDWIN S. BURDELL, professor of Sociology in the department of economics and social science of Massachusetts Institute of Technology, of Catherine Bauer's book "Modern Housing." Dr. Burdell was graduated from M.I.T. in 1920 and from the Harvard Business School in 1921. After a few years in the banking business with his father he traveled extensively for three years in Mexico, Central America, and Europe. He joined the faculty of Ohio State University in 1929 and received his doctor's degree in sociology in 1934. He has held various appointive jobs in the city of Columbus and State of Ohio in the fields of zoning, housing, and unemployment insurance. During 1933–1934 he was state administrator for emergency education for Ohio, putting to work some three thousand unemployed school teachers and organizing classes and recreational facilities for one hundred thousand in eighty-eight Ohio counties.

A.S.M.E. Annual Meeting Dec. 2–6, 1935

THE technical program for the 1935 Annual Meeting, Dec. 2 to 6, of The American Society of Mechanical Engineers will again be confined to three days, Tuesday through Thursday, leaving Monday and Friday free for business and committee meetings. This has been found to be an excellent arrangement and one much appreciated by the members.

Of special interest is the management program arranged for the meeting, which consists of four sessions. The first of these will be on the effect of technological changes on human relations. William L. Batt, nominee for president of the A.S.M.E. for 1936, will preside at this session which will take the form of a symposium in which industrial psychologists, engineers, and executives will participate. There will also be a two-session symposium on costs over which Prof. Walter Rautenstrauch will preside. The subjects discussed will include fundamental industrial costs as well as industrial and power-distribution costs.

In view of the many changes that have been made recently in state laws affecting workers, the session on workers' compensation laws should be of particular interest. This session will probably be held on Wednesday.

The Safety Committee of the A.S.M.E. is arranging a symposium on occupational diseases. A session on education and training in industry is also planned.

The Machine Shop Practice Division will join the Management Division in a luncheon after which it is planned to discuss job shop management from two points of view, planning and scheduling, and the control of production hours in the engineering department. Besides this the division will sponsor two other sessions, one of which will be devoted to cutting research.

A session of broad interest will be that of the Iron and Steel Division on bearing wear. This Division has also scheduled a symposium on recording instruments and methods recently developed in four-high rolling mills. The Wood Industries Session is planning a session on modern timber construction to include a paper on the machinery used.

The Railroad Division is to have a symposium on railroad lubrication, both car and locomotive, and is to cooperate with the Applied Mechanics Division in a session on stresses and oscillations in rail vehicles and axles.

The Applied Mechanics Division will also join with the Power Division in a session on thermodynamics and with the Iron and Steel Division on problems in thin plates and strength of materials.

Shearing stresses and bending and fatigue tests will be discussed at a session on mechanical springs under the auspices of the Research Committee. At the Fan Test Code Session papers on measurement of air flow and head characteristics will be presented.

At the Aeronautic Session the Industrial Aerodynamics Committee will have papers on air flow and fans, pipe bends, and rating of aircraft engines.

Further details of technical sessions will be given in the November issue of MECHANICAL ENGINEERING when the preliminary program will be published.

Spirit of St. Louis Medal to Be Awarded Posthumously to Will Rogers

SINCE the program for the A.S.M.E. Aeronautic Meeting to be held in St. Louis, Mo., October 10 to 12, was announced in the September issue of MECHANICAL ENGINEERING, there have been two interesting additions to it. A special address has been promised on "Foreign Aviation Developments," by a noted European authority in this field. The Spirit of St. Louis Medal, it has been announced, will be awarded posthumously to Will Rogers for his services in advancing aeronautics.

The Committee on this award was composed of Victor Azbe, chairman, Orville Wright, Rear Admiral Cone, Prof. Clark Millikan, William Mayo, and James H. Doolittle, secretary. The decision to award the medal to Mr. Rogers had been made before his death and it is the regret of the Committee that he had not been notified of it. It is planned to award it at the banquet on Friday evening, asking Mrs. Rogers to be present to accept it.

The technical program of about forty papers has been developed by the St. Louis Committee. These papers are being preprinted in booklet form and will be available at $1.50 a copy. Orders should be sent to E. H. Sager, chairman of the St. Louis Section, Washington University, St. Louis, Mo.

A.E.C. News From Washington

IN four months, Congress will reassemble. In the interval between now and the first of January, 1936, it is the task of both industry and of the federal agencies to adjust themselves to the heavy load of legislation. Both Washington and the country are reviewing with soberness the results of emergency legislation passed during the previous sessions of Congress. There are certain to be difficulties in the way of putting some of the legislation into effect.

There continues to be much confusion in Washington and, in spite of public statements to the contrary, a growing feeling on the part of those responsible for administering the legislation that there is a big difference between having new ideas and putting those new ideas into action.

From impressions gained during trips both to the South and to the North within the last four or five weeks it is evident that the "emergency" needs have passed and it is realized that what has been made possible through new legislation now has to be put into action and paid for.

Much of the new legislation, concerning as it does, natural resources, transportation, and construction, directly affects engineers and engineering development. The regulatory legislation covering utility holding companies, motor carriers, the soft-coal industry, and "hot oil," and the increased powers of the TVA and AAA, all tend to centralize authority in Washington over industrial practices and procedure.

The legislation dealing with labor, especially that tending to establish the procedure for collective bargaining by labor, as well as the "social security" system of old-age pensions and unemployment reserves, brings new problems to engineers and to industries employing engineers, in so far as the centralization of regulatory legislation in Washington tends to open channels for constructive study of industrial practices and procedures. There will be many opportunities in industry for men trained in engineering to apply the engineering method of analysis.

Probably in the next ten years, many new fields of opportunity for engineers will be opened, not in the government, but in private industry, because of the need of more intensive analysis of manufacturing costs, of relation of machinery to reduction of labor costs, and of manufacturing methods. Undoubtedly also, there will be an increase in the use of power per man.

WORK RELIEF PROGRAM OF INTEREST TO ENGINEERS

Perhaps the most important and widespread development in Washington of immediate interest to engineers is the Work Relief Program. Over the past month hundreds of projects have been approved by the Works Progress Administration, Public Works Administration, and other federal units. Thousands of additional projects were in the federal hopper on the September 12 deadline set by the President for receipt of applications. In order to spur the program forward toward the winter peak, the federal, state, and local agencies have been instructed to put the projects on contract or force account work by October 22 and to let all necessary contracts not later than December 15.

Under decentralized control, with responsibility largely in the hands of federal personnel in each state, the program invites more than ever the constructive aid of engineering societies and local sections in supplying unbiased advice along technical lines. The fact that services of engineers and contractors may be used on a fee and contract price basis will enable engineers in private practice to enter the program without sacrificing their present business.

Engineering employment under the program may be expected to show a net gain as field activities expand. Some opportunities also may develop under the new administrative staffs required by new legislation, including social security, utility holding companies, coal mining, and motor carriers, but the failure of the Third Deficiency Bill in the last hours of Congress may delay the building of these organizations until after Congress meets in January. These and other acts of Congress have broadened the discretionary power of the Administration and the pending interpretations

of the new powers are likely to include decisions of engineering importance.

Among the measures on which final action was not reached by Congress are: Senator Lewis' bill to change the name of the Department of the Interior to the "Department of Conservation and Works;" the Walsh bill to regulate hours and wages on government contract work; and the Wagner proposal to make it unlawful for persons other than lawyers to make representations before federal agencies. All bills keep the same status into the next session that they attained prior to the recent adjournment.

PWA LOAN RATE

The PWA loan rate for non-federal work, on the 45 per cent grant and 55 per cent loan basis, was reduced from 4 per cent to 3 per cent on May 24 but later was returned to 4 per cent. (See PWA statement elsewhere in this section.) Continuation of the old rate is for the purpose of encouraging communities to use private capital in the financing of reemployment construction projects. Among the non-federal projects recently approved, 130 projects totaling more than 40 millions of dollars will receive the 45 per cent grant while the applicants are using their own credit sources for the remaining 55 per cent.

After a PWA project has been approved, the present regulations permit funds to be made available so that the usual amounts may be drawn for engineering purposes such as preliminary surveys, plans, and specifications.

HIGH LIGHTS OF WORK RELIEF DEVELOPMENTS

High lights of Work Relief developments over the past month, in addition to the heavy volume of new projects approved under WPA, touch upon many fields of engineering activity. River and harbor and flood-control measures are going forward on a large scale under the Corps of Engineers. The Chicago Sanitary District is undertaking the largest sewerage program in the world with new PWA allotments bringing the total to nearly 60 million dollars. The Second Deficiency Act, approved August 12, releases 60 million dollars for public buildings. The Soil Conservation Service has announced a $27,500,000 program in 42 states. Under a $98,830,000 program for balanced land use, the Bureau of Reclamation will undertake additional projects while ten acres of land for every one reclaimed is to be retired from production under the Forest Service and the Resettlement Administration.

Secondary roads will receive not less than 50 million dollars of the 200 millions allotted for highways from the $4,880,000,000 fund. The PWA Housing Division has under way 76 projects of the slum clearance, low-rent housing type and has been acquiring new sites. Additional housing plans are being developed by several agencies. A Power Division under PWA is giving special attention to applications from municipal plants. New surveys by the Bureau of the Census offer engineering opportunities along statistical lines. General collection of data, together with planning work, is continuing under the National Resources Committee and the Water Resources Committee.

1934 Oil-Engine Power Cost Report Now Available

THE 1934 edition of the Oil-Engine Power Cost Report published by the Oil and Gas Power Division of The American Society of Mechanical Engineers, is now available. It contains authoritative information on fuels, lubrication, attendance, and superintendence, supplies, engine and plant repairs. The data have been furnished by 160 oil-engine generating plants. Single copies are priced at $1 each, with reduced rates for orders of ten and over. Requests should be directed to the Publication-Sales Department, A.S.M.E., 29 West 39th St., New York, N. Y.

Western Society of Engineers Elects New Secretary

AT A MEETING of the Board of Direction of the Western Society of Engineers, Leigh S. Keith was elected secretary to succeed Edgar S. Nethercut who was elected secretary emeritus at the same session.

Mr. Nethercut has served the Western Society of Engineers as Secretary and director for 18 years. His retirement was at his own request in order that he might devote his time to travel and historical research in the field of engineering.

Mr. Keith has been active in the society's affairs for more than a decade; and has spent most of his engineering career in Chicago since 1909. He was graduated from the Massachusetts Institute of Technology in electrical engineering in 1900. From 1928 to 1932 he served the Western Society as its treasurer and for the following three years as its vice-president. He has also served on many of its committees and hence has unusual qualifications for his new position.

Diesel-Engine Course, University of California

ANNOUNCEMENT has been made by the Extension Division of the University of California, Berkeley, Calif., that their course in Diesel engineering has been thoroughly revised and is now open for those who wish to enroll. The course presents a general discussion of the elements of the Diesel engine so as to furnish the practical man with fundamental principles which will assist him in the operation and maintenance of the engine.

The revised course has been laid out to cover numerous recent subjects. A few of the important points covered are: Principles and theory of the Diesel engine, types, two and four-stroke-cycle engines, super-charging, precombustion and auxiliary-air-chamber engines, turbulence, Hesselman engines, fuels, various principles involved in fuel pumps and fuel injectors, timing, governors, opposed-piston engines, Diesel-electric rail cars, materials, high-speed engines, torsional vibration, construction features, cooling and lubricating-oil systems, starting and reversing systems, auxiliary equipment, operation, maintenance, and repairs.

Each assignment is fully illustrated by diagrams and blue prints.

The required fee for the course is $7 for students in California, or $10 for those enrolling from points that are outside of California.

For further details one should consult the University of California Extension Division, 301 California Hall, Berkeley, Calif.

Bibliography on Metal Cutting

IN 1930 The American Society of Mechanical Engineers published a "Bibliography on the Cutting of Metals," compiled by Orlan W. Boston, professor of metal processing, University of Michigan, Member, A.S.M.E. The bibliography contained seven hundred references.

Professor Boston has now compiled a new bibliography on this subject which contains 1257 additional references with abstracts. The dates of some of these abstracts overlap those of the 1930 edition, although a majority of them are for the years 1929–1934, inclusive.

References are arranged chronologically by authors, and are indexed by authors and subject matter.

The 1935 bibliography is entitled "A Bibliography on the Cutting of Metals, Part 2." It is published for the author by Edwards Brothers, Inc., Ann Arbor, Mich., bound in cloth, $2.50 per copy.

A.S.M.E. Members Invited to Army Ordnance Association Meeting on October 3

ABERDEEN Proving Ground in Maryland, the Army's establishment for the test and development of military defense equipment, again will be the scene of the Annual Meeting of the Army Ordnance Association on Thursday, October 3, 1935. The program of current tests of ordnance and other military equipment will begin at 10:30 a.m., continuing throughout the day until 5 p.m.

On the preceding evening, Wednesday, October 2, at 7 p.m., the dinner meeting of the Association will be held at the Mayflower Hotel, Washington, D. C. At this session the Ordnance Medal of Merit will be presented to the Hon. Newton D. Baker, Secretary of War, 1916–1921; to the Hon. Bernard M. Baruch, chairman, War Industries Board, 1918, and to Col. Rogers Birnie, U. S. Army, retired, pioneer in modern gun making in the United States. Distinguished speakers will address the gathering.

The members of The American Society of Mechanical Engineers are cordially invited to attend both the Washington and Aberdeen sessions of the Association. Admission to both will be by ticket which may be obtained, together with a reduced railroad-fare certificate and information on special-train schedules, by wiring directly to the executive secretary of the Army Ordnance Association, 807 Mills Building, Washington, D. C.

Result Stories

that prove the value of Republic Meters

IN A PACKING PLANT

A small western meat packing plant operated two boilers which consumed on an average of one car of coal in seven days. Republic instruments were installed on the two boilers and the coal consumption was reduced to one car in nine days. A saving of 11 cars of coal per year—a return which paid for the instruments in 8 month's time.

IN A CREAMERY

Three Republic meters were installed to measure the total steam consumed by the plant, the high pressure and low pressure steam to the buttermilk units. The saving in amount of steam consumed resulting fron the intelligent use of these meters amounted to $1,500.00 the first year. Cost of meters—$975.00

IN A LAUNDRY

The chief engineer of a Chicago laundry writes: "The Republic steam meter, CO_2 meter and draft gage which we installed on our 200 H.P. boiler some two years ago have enabled us to reduce our fuel bill approximately 10%. This is a saving which, in my opinion, few laundries can afford to overlook."

IN A BREWERY

A brewery was about to replace an old 150 H.P., hand fired boiler with a new stoker fired boiler of the same size. Before making the change, they installed a Republic meter on the old boiler and discovered that at peak load they were operating at over 200% of rating. Obviously a larger boiler was needed to handle the load efficiently and to take care of any future expansion. Here the installation of a Republic meter saved the costly mistake of installing too small a boiler.

IN A CEMENT PLANT

A Republic flow meter was installed on each of four kilns to measure the amount of gas consumed. Guided by the information obtained from these meters they were able to reduce their gas consumption by 10%. Cost of meters—$1,200.00. Total saving—$36,000.00 per year.

IN AN INK PLANT

Here three boilers were being operated to carry the plant load. After installing Republic meters on each of the boilers they found that with slight changes in firing methods the load could be carried with only two boilers. This resulted in a saving of about 15 tons of coal per week or 780 tons per year.

SELLING STEAM

A western warehouse was selling steam to one of its tenants at a flat rate of $75.00 per month. The tenant thought that they were being over-charged so a Republic meter was installed to measure the amount of steam actually used—the tenant to be billed accordingly. Now the tenant is paying around $250.00 per month. The meter cost $325.00 and saved the warehouse company $175.00 per month, or $2,100.00 per year.

REPUBLIC
INSTRUMENTS

If similar savings can be made in your plant, you should know about it.

MAIL THIS COUPON TODAY

Gentlemen: I would like to receive, without obligation, information on how Republic meters will enable us to reduce our fuel bill.

FIRM .....

NAME ..... TITLE .....

ADDRESS .....

CITY .....

REPUBLIC FLOW METERS CO.
2232 DIVERSEY PARKWAY, CHICAGO, ILL.

Engineering Societies Library Service Bureau

THE Service Bureau of the Engineering Societies Library serves engineers and technical men who, because of distance or lack of time, are not able to use the library in person.

It searches for information on all phases of engineering, suggests books or magazine articles, prepares bibliographies, tells what is in the bibliographies by means of abstracts, supplies photoprints of material in the Library, and makes foreign-language publications usable by providing accurate translations. In general, the Service Bureau uses the Library for the man who can not visit it in the way in which he would like to use it.

Its investigations are not limited to the extensive resources of the Engineering Societies Library. Engineering Societies Library searchers have access to all libraries in New York City and use them to answer questions in fields more or less related to engineering.

More than one-third of the total number of people using the Library each year can not visit it in person, and as a part of the Engineering Societies Library, the Service Bureau has served engineers in every state of the United States as well as in more than fifty foreign countries.

When a charge must be made for the service requested, the Service Bureau notifies the inquirer of the approximate cost before proceeding with the work. All paid services are rendered at cost.

For further information, write, telephone, or telegraph The Engineering Societies Library, 29 West 39 St., New York, N. Y.

A.G.M.A. Adopts Rating of Speed Reducers

THE American Gear Manufacturers Association has adopted recommended practices for rating helical and herringbone speed reducers and heavy-duty worm-gear speed reducers.

For years, purchasers of this class of equipment have been confronted with the difficult problem of reconciling the conflicting engineering practices that have long prevailed among gear manufacturers. The result has been that in addition to trying to pass on the merits of the individual designs presented by different manufacturers of the same class of equipment, they have had the further difficulty of an unstandardized measure of rating. Simply to say that a reducer is good for so much horsepower at a certain speed, without any reference to the stresses, limitations of wear in the teeth, etc., would be like comparing two electric motors of the same horsepower and speed, with different limits of temperature rise.

The American Gear Manufacturers Association appointed technical committees which labored for several years in working out recommended practices for adoption by the Association. The different types of service that are encountered in everyday use are indicated by service factor or class, so that the buyer of a speed reducer, by specifying an A.G.M.A. rating of the service factor or class wanted, can be assured of knowing what he is getting, and the manufacturer knows that he is in fair competition with another maker of similar equipment.

PWA Interest Rates

CONTINUING the liberalized terms permitting grants of 45 per cent of the cost of non-federal projects in the works program carried on hereafter under PWA, reestablishment of the 4 per cent interest rate on PWA loans and authority to make grants only up to 45 per cent of the cost of a project without loans for the balance have been authorized.

These altered terms were established by the Advisory Committee on Allotments, with Presidential approval to make it easier for private capital to participate in the reemployment effort enhancing the financial resources of the program.

A 4 per cent interest rate was governing under PWA loan procedure from PWA's establishment in the summer of 1933 until May 24, 1935. At that time, the interest rate for non-federal project loans was reduced to 3 per cent and the amount of the outright grant was increased from 30 per cent of the cost of labor and materials which were required on the project to 45 per cent of the cost of the project.

The adjustment of terms is made in an endeavor to reduce the share of the cost borne by the federal government of reemploying men in the works-relief program by making it possible to loan more money instead of making 100 per cent grants to achieve reemployment objectives. It is also to permit communities to supplement the federal grants only through utilization of their own funds or credit resources, opening sources of private capital without recourse to federal loans.

The adjusted terms were established in the desire to place the government in a position where it could cause a dollar's worth of reemployment construction by an expenditure of 45 cents of the emergency relief appropriation of 1935.

The 3 per cent interest rate on non-federal PWA construction loans, together with regulations restricting grants on non-federal projects to instances where government loans were also negotiated, might have had the effect of curtailing the program. In many instances this 3 per cent rate madeit in advisable for communities with reasonably good credit resources to utilize such credit outside the federal government. Prior to the inauguration of the new works-relief program, PWA was able to sell at a substantial profit more than over $85,000,000 worth of bonds it took as security for loans made to communities on a 4 per cent basis. In making such sales a cash profit of approximately $1,000,000 was made. Authority to continue such sales has been granted and the monies realized from such sales may be used to make future loans for construction reemployment purposes.

American Bureau of Welding Reorganizes

THE Annual Report of the American Bureau of Welding, C. A. Adams, member, A.S.M.E., director, announces the reorganization of the Bureau. The section of the report which sets forth the reasons for the organization and the new set-up as an integral part of the activities of the American Welding Society, follows. The American Society of Mechanical Engineers has been represented on the American Bureau of Welding by James Partington.

EXCERPT FROM REPORT OF A.B.W.

"Owing to the fact that the National Research Council finds it no longer possible to sponsor the work of the Bureau and to contribute to its support as it has in the past, and owing to the fact that most of the agencies now cooperating in the work of the Bureau are inactive in that connection, there seems to be no good reason for continuing the present form of organization as such. It has been proposed therefore to make the present work of the Bureau an integral part of the activities of the American Welding Society.

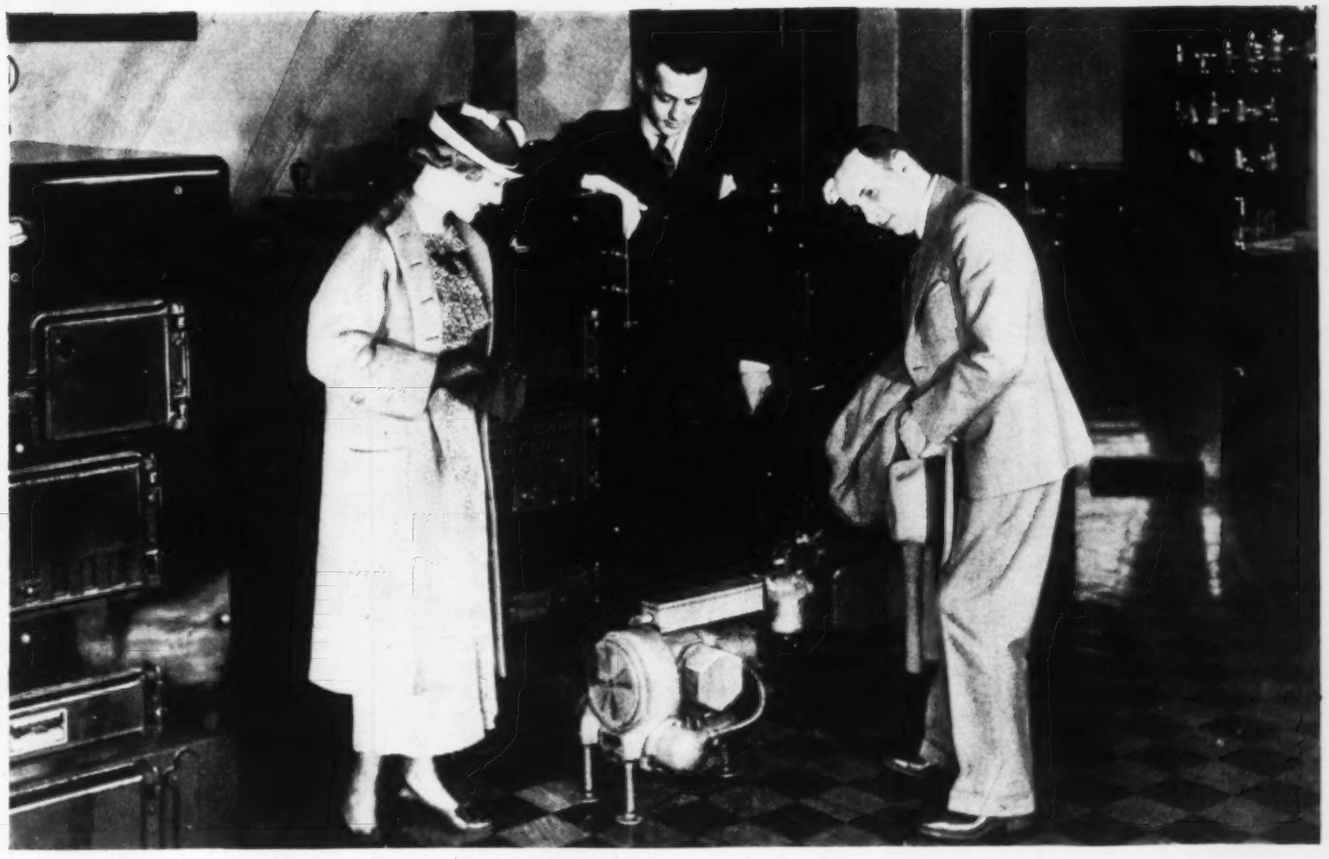
"The Committee on Reclassification of Membership of the American Welding Society considered this whole matter very carefully and recommended that the present Bureau be abolished and that the Society appoint a welding research committee on which would serve the chairmen of the research committees (Fundamental and Structural), a representative of Engineering Foundation, and five others to be appointed by the president. The committee would have the same status as other standing committees of the American Welding Society.

"This matter was duly considered by the Board of Directors of the American Welding Society and while the Board generally approved this recommendation, it felt it desirable to ascertain the wishes of the National Research Council and to permit a discussion of this whole situation by members of the American Bureau of Welding.

"After due deliberation the National Research Council indicated that it was necessary to limit its expenditure in every possible way, which made it impossible for them to remain a joint sponsor and to contribute toward the maintenance of the American Bureau of Welding as in the past. On behalf of the National Research Council, Dr. Bowman expressed his regret that it was necessary to make such a decision and indicated that the Council appreciates the high quality of the work done by the Bureau.

"This matter was considered at a meeting of the American Bureau of Welding on April 25. That body voted to disband and to recommend to the American Welding Society the appointment of a Research Committee and the transference of the two subcommittees on (*a*) Structural Steel and (*b*) Fundamental Research.

"Later in the evening of the same day the Board of Directors voted to take over the sponsorship of the present American Bureau of Welding and the two aforementioned Committees."



MODERN BUYERS SHOP LOOK AND LISTEN

A MID-WEST maker of oil burners found that his customers had just one objection to his product—the noise caused by vibration. Prospective buyers stopped and looked but they also *listened*. He asked Goodrich to design sheer-type mountings for motor and blower. Noise disappeared, complaints stopped—and sales climbed.

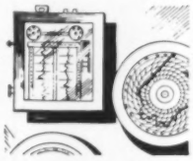
Five leading motor makers now mount their motors on rubber. They know that vibration is out of date, and can hasten a product toward obsolescence.

And vibration is usually needless. Goodrich can attach rubber to metal or almost any other material of which your product may be made. The bond can resist pressure of hundreds of pounds per square inch, and the rubber used can be made to last for years, resist heat, cold, air, water, oil, chemicals, and can be odorless and tasteless and in practically any color, shape or texture.

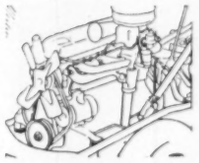
Silence and freedom from vibration can be powerful sales arguments today —for industrial equipment as well as for consumer goods. Goodrich engineers have had years of successful experience in noise elimination and vibration dampening. It is at your disposal if you will write The B. F. Goodrich Company, Mechanical Rubber Goods Division, Akron, Ohio.

Goodrich

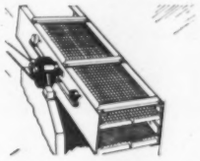
ALL *product problems* IN RUBBER



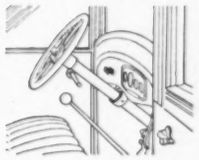
• In power houses, hospitals, ships, etc., the accuracy of delicate recording instruments is increased by Goodrich rubber footings which prevent floor shocks from passing to the instruments.



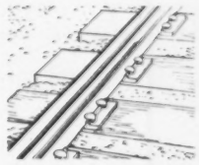
• Modern high speeds in automobiles and streamlined trains would be impractical were it not for rubber mountings—many developed by Goodrich—to help absorb the vibration.



• Vibrating screens caused floor vibration which reduced accuracy, increased fatigue of workers. Goodrich rubber mountings isolate the vibration and end trouble.



• In the steering mechanism of many automobiles a Goodrich rubber bushing absorbs road and motor vibration, and so keeps tremor and shock from the wheel and the driver's wrists.



• Goodrich rubber cushions inserted in specially designed railroad tie plates prolong the life of ties by isolating vibration of the heavy rails, and reduce maintenance cost of equipment.

• Familiar example of rubber for absorption of shock and noise is the rubber heel, especially as perfected by Goodrich with rubber built on a wood core to increase comfort and useful life.